TWENTY-THIRD AND TWENTY-FOURTH ANNUAL REPORT

OF THE

Quebec Society for the Protection of Plants

1930-1932

Supplement to the report of the Minister of Agriculture

Printed by order of the Legislature

THE PRINTER TO HIS MOST EXCELLENT MAJESTY THE KING

QUEBEC

1932

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1930 - 1932

To the Honourable J. Adelard Godbout,

Minister of Agriculture,

Quebec.

Sir:—

I have the honour to present herewith the twenty third and twenty fourth Annual Report of the Quebec Society for the Protection of Plants, containing the proceedings of the winter meetings of the Society, which were held at Macdonald College on April 8th and 9th, 1931 and on April 20th and 21st, 1932.

Included are the papers that were read, and the reports of the officers of the Society.

I have the honour to be,

Sir,

Your obedient servant,

E. Melville DuPorte,

Secretary-Treasurer.

Macdonald College, Quebec.

OFFICERS OF THE SOCIETY—1930-1932

President:—Professor Georges Maheux, Dept. of Agriculture, Quebec.

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Delegates to the Ont. Ent. Society:—Rev. Father Leopold, Dr. E. Melville DuPorte, Dr. W. H. Brittain.

FINANCIAL STATEMENT 1930 - 1932

MACDONALD COLLEGE, QUE., CANADA,
June 20th, 1932.

Receipts 1930-1931

Balance in bank, 1929-1930	$ 140.56
Government Grant	250.00
Interest	.99
	$ 391.55

Expenditure 1930-1931

Secretary's stipend	$ 50.00
Clerical, postage, etc	16.98
Separates from annual report	58.00
Expenses of annual meeting	21.72
Delegate to Ont. Ent. Society	24.85
Expenses of guest speaker, annual meeting	34.12
Balance in bank	185.88
	$ 391.55

Receipts 1931-1932

Balance in bank, 1930–1931	$ 185.88
Interest	2.18
	$ 188.06

Expenditure 1931-1932

Secretary's stipend	$ 50.00
Delegate to the Ont. Ent. Society	41.35
Separates from annual report	49.50
Expenses of annual meeting	8.56
Postage, clerical, etc	5.00
Balance in bank	33.65
	$ 188.06

Audited and found correct.

GEORGES MAHEUX,
President.

J. G. COULSON,
Auditor.

E. MELVILLE DUPORTE,
Sec.-treas.

LIST OF MEMBERS 1930-32

Adams, John	C. E. F. Dept. of Agr., Ottawa.
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Arsenault, Félix	Rimouski.
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Cartier, R. D.	L'Assomption.
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Dickson, Prof. F.	Univ. of B. C. Vancouver.
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Dustan, A.	Entom. Branch, Ottawa.
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Fontanel, Rev. Prof.	St. Mary's College, Montreal.
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Guenette, L.	Forest Service, Quebec.

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de Gryse, J. J	Entomological Branch, Ottawa.
Gussow, H. T	C. E. F., Dept. of Agriculture, Ottawa.
Hale, J. D	Forest Products Laboratory, Ottawa.
Hammond, G. H	Entom. Branch, Ottawa.
Herman, F. A	Div. of Chemistry, C. E. F., Ottawa.
Hockey, J. F	Lab. of Plant Pathology, Kentville, N. S.
Honoré, Rev. Father	La Trappe, Que.
Howatt, J	Lab. of Plant Path., Charlottetown, P. E. I
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Hutchings, C. B	Entomological Branch, Dept. of Agric., Ottawa.
Jenkins, M. H	Experimental Farm, Nappan, N. S.
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Keenan, W. N	Ent. Branch, Ottawa.
Kieffer, H. F	Forest Service, Quebec.
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Lagloire, P	5727, St. Urbain St., Montreal.
La Rue, L	Ste. Anne de la Pérade, Que.
Lavallée, E	Macdonald College.
Lavoie, J. H	Horticultural Bureau, Quebec.
Levasseur, Rev. Paul	Ste. Anne de la Pocatière.
Lloyd, Prof. F. E	McGill University, Montreal.
Lods, E. A	Macdonald College.
MacCallum, A. W	C. E. F., Dept. of Agriculture, Ottawa.
MacClement, Dr. W. T	Queen's University, Kingston, Ont.
Machacek, Dr. J. E	Macdonald College.
Maheux, G	Provincial Entomologist, Quebec.
Major, T. G	Tobacco Division, Dept. of Agriculture, Ottawa.
Maltais, J. B	Hemmingford, Que.
McLaine, L	Ent. Branch, Ottawa.
McLennan, A. H	Ontario Agricultural College, Guelph, Ont.
McMahon, E. A	John Cowan Chemical Co., Montreal.
McOuat, J. E	Pointe Claire, Que.
McRostie, Dr. G. P	C. E. F., Ottawa.
Ménard, J. H	Forestry School, Berthierville.
Michaud, G	Dept. Agric., Quebec.
Moore, G. A	159, Querbes Ave., Outremont.
Montreuil, E	L'Assomption.
Mougeot, R	Dept. Agric., Quebec.
Newton, Miss Dorothy	Macdonald College, P. Q.
Nolet, Louis	Collège de Levis, P. Q.
Painter, R. H	Ent. Branch, Ottawa.
Parent, Nazaire	Dept. of Agriculture, Que
Pasquet, Jos	Ste. Anne de la Pocatière.
Pepin, Dr. A	Dept. of Agriculture, Que.
Perrault, C	Ste. Anne de la Pocatière.
Petch, C. E	Hemmingford, Que.
Petraz, Mr	Horticultural Service, Quebec.
Piché, G. C	Chief Forester, Quebec.
Pomerleau, René	Ste. Anne de la Pocatière.
Reid, Peter	Chateauguay Basin, Que.
Racicot, H. N	Division of Botany, Ottawa.
Raymond, L. C	Macdonald College.
Raynaud, Mr	Berthierville, Que.
Richardson, J. K	Fredericton, N. B.
Robert, H	Horticultural Serv., édifice "La Sauvegarde", Mont.
Robitaille, Rev. Father	Laval University, Quebec.
Rodrigue, Abbé W	Ste. Anne de la Pocatière.
Roy, Henri	École des Gardes, Berthierville.
Rousseau, J	University of Montreal.
Ryan, W. St. G	379, Common St., Montreal.
Saunders, L. G	Univ. of Sas., Saskatoon.
Savoie, F. N	Dept. of Agriculture, Quebec.
Simard, J	Dept. of Agriculture, Quebec.
Simmons, P. M	Lab. of Plant Path., Saskatoon, Sask.

Stevenson, J. N.	Gardenvale, Que.
Stewart, K.	Ent. Lab., Indian Head, Sask.
Stohr, Rev. L. M.	Ironside, Que.
Strickland, E. H.	Edmondton, Alberta.
Suit, Dr. R. F.	Macdonald College.
Summerby, Prof. R.	Macdonald College.
Swaine, Dr. J. M.	Entomological Branch, Dept. of Agric., Ottawa.
Tawse, W. J.	4573 Marcil Ave., Montreal
Taylor, C. F.	Wolfville, N. S.
Tessier, G.	Forest Service, Quebec.
Twinn, C. R.	Entom. Branch, Ottawa.
Vanterpool, T. C.	University of Saskatchewan.
Victorin, Rev. Bro.	University of Montreal, Montreal.
Whetzel, Prof. H.	Cornell Univ. Ithaca, N. Y.
White, R. M.	Entom. Lab. Tressbank, Man.
White, A. E.	5059, Western Ave., Montreal.
Whitehead, W. E.	Macdonald College, Que.
Willey, Dr. A.	McGill University, Montreal.
Winn, A. F.	McGill University.

HONORARY MEMBERS

F. C. Harrison, D.Sc., McGill University, Montreal.
Rev. Father Superior Dom Pacome Gaboury, La Trappe, Que.
Rev. Father Superior, Ste. Anne de la Pocatière.
A. Gibson, Esq., Dominion Entomologist, Ottawa.
Hon. Minister of Crown Lands and Forests, Quebec.
Rev. Father Leopold, D.Sc.Agr., La Trappe, Que.
Prof. Francis Lloyd, M.A., F. R. S. C., McGill University.
Hon. A. Godbout, B.A., B.S.A., Quebec.
Dean G. H. Barton, B.S.A., D.Sc.A., Macdonald College.

TWENTY-THIRD ANNUAL MEETING

The twenty-third annual meeting of the Quebec Society for the Protection of Plants was held in the Biology Building, Macdonald College on April 8th and 9th 1931.

On the afternoon of April 8th there was held a symposium in the form of a debate on the effectiveness and expediency of Plant Quarantine as a method of plant protection. At 8.00 p.m. the meeting was addressed by the guest speaker. Dr. A. P. Clinton, Botanist to the Connecticut Agricultural Station, and Lecturer in Forest Pathology, Yale University. Dr. Clinton spoke on "Three Destructive Diseases of Trees—Chestnut Blight, White Pine Blister Rust and Willow Scab." The great interest manifested by the audience in this address was in no small part due to the very obvious enthusiasm of the speaker in his chosen work.

Following the address there was an informal smoker in the Men's Residence.

At 9.00 a.m. April 9th there was a series of papers on Insects and Diseases of Vegetables and Flowers.

Most of the papers and addresses are included in this report.

TWENTY-FOURTH ANNUAL MEETING

The twenty-fourth annual meeting was held at Macdonald College on Wednesday and Thursday April 20th and 21st 1932.

The first session for the reading of papers was held on Wednesday at 2.00 p.m. At 8.00 p.m. Dr. Ralph DeLury gave an extremely interesting address on "Sun Spots, the Weather and Life." Dr. G. H. Barton, Dean of the Faculty of Agriculture, Macdonald College, gave an address of welcome in which he stressed the increased responsibility of the technical services at the present time.

At 9.00 a.m. on Thursday there was a further session for the reading of papers, followed by a business meeting of the Society.

At the business meeting the treasurer's report was read and accepted. The following officers for the period 1932-1934 were then elected.

President.—Prof. J. G. Coulson, Macdonald College.
Vice-President.—Mr. Omer Caron, Dept. of Agriculture, Quebec.
Secretary-Treasurer.—Dr. E. Melville DuPorte, Macdonald College.
Asst. Secretary.—Prof. Georges Maheux, Dept. of Agriculture, Quebec.
Directors.
Revd. Father Leopold D.Sc.Ag., La Trappe, Que.
Dr. W. H. Brittain, Macdonald College.
Prof. J. G. Coulson, Macdonald Collge.
H. Racicot, Esq., Botanical Division, C.E.F., Ottawa.
Prof. E. Campagna, School of Agriculture, Ste. Anne de la Pocatière, Que.
T. G. Major, Esq., Tobacco Division, C.E.F., Ottawa.
A. Dustan, Esq., Entomological Branch, Ottawa.
R. Pomerleau, Esq., Forest Nursery, Berthierville, Que.
B. Baribeau, Esq., Experimental Station, Ste. Anne de la Pocatière, Que.
Auditor.—F. Godbout, Esq., Dept of Agriculture, Quebec.
Delegate to the Royal Society.—The President.
Delegates to the Ontario Entomological Society.—Father Leopold, Dr. DuPorte, Dr. Brittain.

The Honourable Mr. Adelard Godbout, Minister of Agriculture for Quebec, and Dr. G. H. Barton, Dean of the Faculty of Agriculture, McGill University were elected Honorary Members of the Society. The following new members were elected:—C. Perrault, R. Bordeleau, G. Gauthier, L. La Rue, Dr. R. F. Suit.

It was decided to hold the annual meeting in the future at Macdonald College, on the day preceding or on the day following the meetings of the Quebec Pomological Society.

NOTES ON THREE SERIOUS TREE DISEASES *

C. P. Clinton.

During the past twenty-five years, I have been interested in first the Chestnut Blight, then the White Pine Blister Rust and recently the Willow Scab. I wish here to make a few remarks concerning each without going into any details concerning these special fungi or their injurious effect on the special hosts. I do wish, however, to bring before you a few observations and experiments dealing with each as revealed in my and Dr. McCormick's more recent work.

Chestnut Blight, *Endothia parasitica.*

I start with the chestnut blight since this was the first to receive my especial attention. It is not so important to Canadians because of the infrequency of the host even before the blight appeared but I understand that this disease has also been found here. I wish to consider it briefly from a Connecticut view point, which is practically that of New England, under the three headings: (1) condition of native chestnuts in our woodlands; (2) recently planted chestnut plots; (3) recent infections with artificial cultures.

(1) We hear a lot from scientific and popular writers (about chestnuts here in the north that have practically disappeared through the blight) of the possibility of resistant trees surviving from which new forests might be established, or the likelihood of the blight dying out so that the surviving seedlings and sprouts may escape final destruction. I wish to record my opinion concerning these statements.

We certainly have no healthy old trees and practically no living diseased ones in Connecticut. In 1927 we heard of what seemed to be one of the last of these old trees. Various newspaper articles appeared concerning this tree of which the following is a sample: "It is one of the few trees of its kind in New England--that is, it regularly yields a good crop of chestnuts. It is so important to the forestry experts that they purpose making an effort to save the nuts for seed, in the hope that chestnut trees can again be grown in New England and made a source of profit to farmers. In order to prevent the nuts from being carried off by squirrels, it is purposed to enclose the tree with a fine mesh wire, with a screen at the base to catch whatever burrs may fall. Why this tree at Woodville managed to escape destruction no one knows."

Neither did it escape destruction. With Mr. Filley, our Station Forester, and the owner, we visited the tree that fall and much to the owner's surprise

* The talk delivered before the Quebec Society for the Protection of Plants was informal and based on lantern slides to illustrate the same. Naturally it cannot be produced here, hence this article deals chiefly with some of our more recent investigations, including the year 1931 and omits the previous contributions made by many other investigators also referred to in our talk.

this supposedly fine tree had gone back since he had seen it the previous year. All that was left living was a piece of bark about a foot wide on the north side of the tree extending about half way up the trunk where three branches, each about three inches in diameter, were still alive but infected and one branch, one inch in diameter, seemed to be free. All told there were four chestnut burrs on these living branches. The tree apparently could not survive more than another year at the most.

However, this was not the last old tree that survived in Connecticut, since in the fall of 1931 we again saw another old tree, two feet across, that had a similar but narrower streak of living bark on the north side from the end of which, near the middle of the tree, proceded three small branches bearing one to two hundred living leaves. This dead-living tree also is doomed shortly, so we can safely say that all the old trees are dead or practically dead and there is no hope of propagating new resistant trees from them in Connecticut. Perhaps this may be done elsewhere but, personally, I do not count much on it because of the lack of the "so-called" resistance developed in trees in one generation.

As regards the sprouts from old trees, I make the following statements. There are practically no sprouts on dead trees here that have been left standing. Sprouts from the cut stumps are not so numerous or as large as a few years ago. The largest sprouts that I have found, either infected or healthy, are not over four or five inches at the base, or over thirty feet at the most in height. I have however, seen a few sprouts, both infected and healthy, about this size this year. Because of the disappearance of the old infected trees and the lesser number of infected sprouts, we occasionally find where just one or two sprouts survive that they have succeeded in escaping infection. Furthermore we find that, because of the scarcity of trees and sprouts, the blight fungus is very much more limited in its development and so there is less likelihood of its spread to the still living healthy sprouts.

As regards seedling chestnuts we still have a fairly large number in our woods. Like the sprouts the largest ones, either infected or healthy, are four or five inches in diameter at the base, and about twenty to thirty feet tall. These large seedlings, however, are few in number. The small seedlings, one to six feet tall and less than half an inch in diameter, are still present in considerable numbers. This year I found that most of them seem to be quite vigorous and often free from blight. It is to these younger and more isolated seedlings that I look for the survival of the chestnut, because of the lessening opportunity for infection and the possibility that the blight itself may gradually lose its virulence as a parasite.

As to the so-called resistant trees in nature, I do not look for help. I have never seen what I would call a resistant tree or seedling and all of the trees that have been called to our attention have been either (*a*) some other tree than the native chestnut, such as horsechestnuts, etc., (*b*) Asiatic or other species that are known to have more or less resistance to blight and (*c*) native trees that while they have outlived other trees have finally died.

(2) Because of inquiries concerning what would happen to the chestnuts when the blight began to decline and the likelihood of planted seedlings escaping infection when this occurred, the writer and Mr. Filley in 1924 began to buy chestnuts from the south for growing seedlings. Most years since that time we have planted the nuts at the Station in the fall, leaving them there for a year, and then have transplanted the one-year seedlings in five selected localities in different parts of the state where chestnuts have died but where the sources of infection were perhaps less than usual. The first lot of three hundred seedlings was set out in the spring of 1926. In 1927, there were also planted about one thousand seedlings; in 1928 over thirteen hundred; in 1930, approximately five hundred. This fall, 1931, a new lot of seeds has been obtained for germination next spring.

The results of these experiments so far have been as follows. We lost about half of the nuts through worms contained in them before being placed in the seed beds. The seedlings were planted in the field by the ordinary method of making a hole with a mattock every three feet, placing the wet roots of the seedling in the same and tramping down the earth with the feet. We found that a large percentage failed to survive a year because of dry weather, competition, etc., so that eventually, with at least two drought years, less than 40% of the seedlings now survive. So far we have found very few killed by the blight and we doubt whether the blight will be much of a factor until the seedlings obtain considerable size. Finally the growth of these seedlings has been very slow even those now out five years. In some cases the latter are not much larger than those recently put out. Those planted in the open or under too much shade have on the whole done poorer than those with moderate shade.

We have had similar trouble from drought with the few disease resistant species sent us at different times by the government and planted at the Station wood lot at Mt. Carmel. Our main trouble so far, therefore, has been to get the seedlings to live long enough in a healthy condition to be subject to the blight later on.

(3) We have had in culture, a number of years, the three saprophytic relatives of the chestnut blight (*Endothia parasitica*, *E.gyrosa* and *E.radicalis* var.*Mississippiensis*) and also various cultures of chestnut blight (*E.parasitica*) that have been grown artificially for from one to twenty-one years. We wished to learn if carrying these fungi in artificial media affected their parasitic or saprophytic nature when they were inoculated in isolated cultivated chestnut seedlings. Consequently in the summer of 1931, we tried them out using five to ten plants for each inoculation, with a similar number of checks, of the four fungi. All of the checks remained healthy and also all of the plants inoculated with the three saprophytic fungi. With the chestnut blight, the chesnuts inoculated with the two cultures grown saprophytically for seven and twenty-one years also remained healthy. While with those inoculated with the recently obtained blight cultures, one two years old and the other less than a year, every inoculated tree took.

If we can duplicate the results with these and other old cultures of the chestnut blight, to be sure of no error, we can then claim that continued culture as a saprophyte causes the chestnut blight to lose its virulence. If this is so, then may we not expect that the same thing might gradually occur in nature, and thereby have some hope that the chestnut may again come back, as it did over a hundred years ago, following the unknown trouble that killed many of the trees in the south.

White Pine Blister Rust, *Cronartium ribicola.*

We have previously published, in part, Dr. McCormick's and my work on the blister rust. We showed how infection (indicated by yellow spots) took place through the needles, (chiefly the one, two or rarely three year old needles) in nature in the fall, and how the fungus works down through the fibro-vascular system into the stems, where later, it breaks out as the first evidence of infection to the casual observer. We got so far that we were able to observe, under the microscope where infection had taken place in the leaves which had been exposed to the germinating sporidia only from one to three days. In indoor inoculations the first sign of infection to the naked eye is not seen before one or two months; while the outdoor natural infection probably does not show until the following spring. We also found results of needle infection due to our other common pine stemrust, known as *Cronartium Comptoniae*, which infects a variety of pines.

We also showed to our own satisfaction, and I hope to others, that the white pine rust could, at least artificially, infect other than five-needle pines, such as those having two and three needles. The only reason that these other species are not attacked in nature is, to my mind, because they are not often associated with Ribes producing telial infection, or perhaps they are and the botanist finding such an infected pine calls it by some other rust name.

We found in these artificial inoculations with young pine seedlings that there was a great difference in susceptibility to this rust. Of the 28 different species of pine used there were ten that failed entirely of infection. There were seven species where we got poor leaf infection but which failed to grow further. There were six species that fave fair leaf infection but were doubtful as to stem infection. These were as follows: *Pinus Lambertiana* (5 needles), *P. tuberculata* (3), *P. Laricio* (2), *P. ponderosa* (3), *P. Sabiniana* (3) and *P. insignis* (3). There were, however, four species, other than *Pinus Strobus*, where good needle infection was followed with evident stem infection. These were *P. canariensis* (3), *P. Pinea* (2), *P. Coulteri* (3), and *P. edulis* (3). With these last species we were also able to develop pycnia and pycniospores on the stems and to carry them along usually as far as we could with the white pine.

Pycnia, with spores, were sometimes produced when the infections were less than a year old. However, we were never able to produce the aecial stage, even on the white pines, when the seedlings were kept for observation for two or three years and longer. We are not quite sure of the reasons for this; possibly

it may have been because the seedlings were often killed by too vigorous infection. On the other hand we have often wondered whether or not there was some unknown factor like artificially mixing the pycniospores together from different infections, such as has recently been shown to be the case when barberry leaves are artificially infected to produce aecidia.

Another reason for discussing the blister rust is to call to your attention some of the factors that favor or prevent pine infection in nature as well as in the laboratory. You are aware that certain years are much more favorable for pine infection than are others. It is quite doutbful if general infections occur on the average more frequently then once in four years. Observers have aimed to determine approximately those years by counting the number of internodes that have developed above the cankered areas.

We know that, besides the presence of both the alternate hosts, we must have the Ribes infected with the telial stage fairly near the pines. We know that certain Ribes, like cultivated black currants, are likely to produce the telial stage in abundance all over the leaves; that other Ribes, like the skunk currant, are often present in great abundance in infected localities. Besides these susceptible and abundant Ribes, we need certain weather conditions to favor the germination of the telia, the production of a maximum of sporidia and the carrying of these under favorable conditions to the pine needles where their germination is also favored. We know also that these conditions must occur, ordinarily, sometime between the middle of August and the middle of October. These weather factors are the optimum conditions of moisture and temperature, and favorable safe winds as the carrying agent. It is likely that these conditions do not generally exist during the late summer and fall. The year that gives one or more favorable infection periods of this nature is the year thatl produces the most rust cankers on the pines. I understand from Riley, of the U.S. Department here in Connecticut, that he considers 1931 as such a favorabe year.

Yet knowing these factors we have not succeeded in producing uniformly successful artificial infection experiments. We have apparently gained little from experience, since our last attempt was the least successful of any of our inoculations. We have frequently missed some important factor. No doubt it was at times because our infection material was in poor condition, such as too old telia or too little in amount. Again it might have been because we kept the Ribes leaves too wet or the pines too dry; or we may have lacked air currants to carry the sporidia from the currant leaves to the pine needles. Our chief trouble, however, we believe to have been too high temperatures. Usually we infected the pine seedlings under bell jars, placing the infected Ribes leaves in various ways above them and tried to keep the plants moist and exposed to day-light.

The fall of 1931 we again tried to see if we could be more successful than nature seems to be. We exposed two lots of seedlings of some eighteen different species of pines. These were all this year's seedling grown in crocks, each crock containing from one to several or in a few cases as many as forty young plants.

We designed a Wardian glass case containing a humidifier, to send out ample atmospheric moisture, and a Frigidaire cooler, to reduce the temperature as low as 50° F. if necessary. We placed the crocks of each set at different times in the bottom of the case, atomized their leaves with water occasionally, and on a wire rack over them placed an abundance of currant leaves containing telia in prime condition for germination. We turned on the humidifier to germinate the telia and afterwards turned it off to dry out somewhat the leaves. We introduced artificial air currants to blow the sporidia down on the pine needles. All we have to do now is to wait results for the infection spots to appear. If these fail on the susceptible species of pines, I will conclude that while I may be a scientist I am at least a poor practitioner, much worse than old mother nature who has to consider the survival of both the pines and the Ribes as well as the rust.

Willow Scab, *Fusicladium saliciperdum.*

Let me conclude with a few words concerning the willow scab, a subject on which I have spoken to some of you before. This, too, is in collaboration with Dr. McCormick. I, and others, have found this disease in many places in all of the New England states, though least prominently in Rhode Island. I found it in Quebec, beginning half way between New Hampshire and the city of Quebec, and from there all the way along the St. Lawrence river, up and around the other side of the Gaspé peninsula; also in many places in New Brunswick, Prince Edward's Island, Nova Scotia proper and Cape Breton Island. Great damage has been done in some of these Canadian provinces, where the willow is a common street and shade tree. In New York it has been found by various observers as far west as Ithaca. I have also collected the disease from one place in England. We have cultures of the fungus made from leaves from many of these localities. In 1929 and especially in 1930, due to the droughts, the disease seemed to be going into a decline but in 1931, due to the wet spring, it came back again with considerable vigor where we observed it in Connecticut.

The yellow-twig willow, *Salix alba* var. *vitellina*, is the chief shade tree that has suffered, so that in many localities the tree has been practically annihilated. We have seen little injury to the white willow *S. alba*, and none to the true weeping willow, *S. Babylonica*, although it has done some damage to Thurlow's weeping willow, *S. elegantissima*. *S. cordata*, the common shrub willow along streams, is also a favorite host.

We have found definite infections on the twigs in early spring, producing conidia before and when the leaves were coming out. We have seen infection of the young leaves immediately beneath these infected twigs, thus showing how the fungus carries over the winter. We have never been able to find the mature Venturia or asco stage on the old leaves, though we have searched for it in New England and in Canada. We did, however, find a true Venturia on dead willow leaves that we thought might be this stage but, when Dr. McCormick succeeded in making cultures, it produced a saprophytic Cladosporium as its conidial

stage. I am wondering if this is the Venturia that Aderhold and others have described in Europe as its mature stage.

We have tried all sorts of ways to secure the Venturia from our cultures of the Fusicladium which came from the diseased willow leaves. We have sought this because there was frequently a tendency of the cultures to form what seemed to be immature perithecia. Many one-spore cultures have been crossed with others and with mixed cultures from a variety of sources without any definite results. Finally by mixing cultures from Canada and New England and keeping them under cold conditions for many weeks, we succeeded in a few cases in producing a limited number of perithecia and mature ascospores. These ascospores differed from those produced by the saprophytic Venturia found on old willow leaves in nature and from those figures by Aderhold. They agreed more nearly with the ascospores figured by Aderhold as being characteristic of the Poplar scab, to which the willow scab is the most nearly related of any of our Fusicladium species.

In conclusion we can state that we have also isolated cultures of the Physalospora disease of the willow that British writers believe to be the cause of the willow disease. We have this fungus obtained from native willows gathered in Japan, from Canada and New England. We do not deny that this is a parasite, problably more of a real parasite than the Fusicladium, and that it may cause infection of willow twigs and leaves, particularly the mature leaves, Yet we believe that both Natrass of England and Dennis of Scotland are mistaken when they say that *Fusicladium saliciperdum* cannot infect living willows. Further we believe that the latter fungus is the chief cause of the willow disease, since it is the very young leaves during wet weather that are killed when they first come out, or while young and still growing. It is this destruction that causes the death of the willows later through starvation and not the later canker and leaf-spotting fungus which may be largely due to the Physalospora.

So far we have secured a greater amount of infection from the Fusicladium than from the Physalospora, though the abundant spore production of the latter favors greater degree of infection. Finally there is the matter of the similar poplar disease caused by the closely related *Fusicladium radiosum*, for which no one yet has isolated a Physalospora as the cause of the poplar disease.

Early spraying is the chief remedy against this disease, but it is rather expensive; it requires four to five sprayings to control it after the fungus once gets a fair start on the trees. Our four sprayed trees at Norfolk are the only ones in their immediate vicinity that are still alive, but in 1931 they developed the disease abundantly because they were not further protected that spring by spraying.

THE EFFECT OF SOME PHYSICAL FACTORS ON ONION MAGGOT INFESTATIONS IN LIGHT AND HEAVY SOILS

By Alan G. Dustan, Entomological Branch, Ottawa.

While carrying on control studies in connection with the onion maggot in the vicinity of Ottawa it was frequently noticed that some fields, and even certain portions of the same field, supported a much heavier infestation than others. At first this was very puzzling since there seemed to be no apparent reason for such differences in infestation. To the casual observer these fields differed very little from each other and where the variation took place in the same field no reason whatsoever could be given for such a condition. When this peculiarity had been under observation over a period of years and the disparity in abundance found to be constant season after season, a more determined effort was made to learn the cause, or causes, of this peculiar variation. It was found upon study that those fields, or portions of fields, supporting a heavy onion maggot population were composed of "light" soil while the poorly populated fields were of a clayey nature. Further study revealed the fact that, in general, it could be stated that onions growing in light soils were heavily infested whereas the plants standing in heavy soils were practically free from attack; at any rate were much less heavily attacked than the onions planted in sandy soils.

It was felt that this fact might be made use of in assisting the grower, if it were possible to find out just what factors were bringing about such a condition and the soils to which these factors were peculiar. In other words, if it was learned that these factors were present in sufficient abundance in soils containing, let us say, 25 per cent or over of silt it might be possible, after analysing the soil of a prospective onion grower, to advise him whether or not onions grown on such soil would probably be heavily infested or but slightly attacked. Such a service would undoubtedly be of great value to the producer, since if it were found that all signs pointed to a heavy onion maggot population, should a crop be planted on any given soil, it would be wiser to change to one less liable to infestation. This was the chief end in view when this study was commenced.

It should be pointed out before a discussion of the problem is entered into that the study is by no means complete and that this paper should be looked upon in the light of a progress report rather than a summary of a completed investigation.

The work in connection with this problem was carried on in a field in the vicinity of Aylmer, P.Q. The field in question had been under observation for several years, due to the fact that the onions at one end were noticed to be always very heavily attacked while the crop at the other end was damaged only slightly. When this condition was found to be constant from year to year a physical analysis of the soil in different parts of the field was made by the Divi-

sion of Chemistry at the Central Experimental Farm. This analysis showed that at the end of the field where the infestation was light the total sand ran about 58 per cent and the percentage of silt and clay 21 per cent. In the area of lighter infestation the sand totalled about 45 per cent only while there was practically 27 per cent of silt and clay. The former was classed as sandy loam and the latter as clay loam. An intermediate soil was found between these two extremes. Study points were laid out in the sandy loam and clay loam ends of the field and also in the intermediate zone.

One phase of this study was the measurement of certain physical factors in the three different types of soil and the correlating of these with the effect on onion maggot infestation. It was most important that information be gained regarding the stage or stages in the life-history of the insect when the numerical reduction in clay soils took place and also what factors were responsible in bringing this reduction about. It was hoped to gain such information from this study of physical factors operating in the soils under observation.

In this paper consideration will be given to the following factors: (1) temperature, (2) soil moisture, (3) hydrogen ion concentration, (4) texture and (5) chemical composition.

Temperature.—Soil temperature records have been taken daily over a period of two years from May 1 to September 15 in light, medium and heavy soils. Self-registering maximum and minimum thermometers were used throughout and records taken at a depth of one and two inches, since it was felt that onion maggot activity was confined chiefly to these depths. At depths of both one and two inches practically no variation in the minimum readings was noted at any time during the season in the different soils. The same was true of the maximum records at the two inch depth. At a depth of one inch, however, a very considerable variation was seen in the maximum readings. It was found in general that during hot spells the temperature in the clay soils ran very much higher than in the sandy areas, a difference of 10-12 degrees being not uncommon. When this was noticed additional thermometers were secured and a short test run with the instruments buried just below the soil surface. When this was done the temperature in the clay soils was observed to rise as high as 124 degrees which was much higher than similar readings taken in the light soil at the other end of the field. The question at once arose as to what effect this would have on the eggs, and tests carried out in the field and checked in an electric oven in the laboratory showed that when eggs were subjected to a temperature of 124 degrees that one hundred per cent were killed. This question of temperatures at the soil surface where the eggs are found will have to be investigated in greater detail next summer but tests made to date, although on a small scale, point very strongly to the possibility that many eggs are killed by excessive heat in the heavier types of soils and this may account in part, at any rate, for the reduced infestations in such soils.

Soil Moisture.—Through the kindness of Mr. H. S. Hammond of the Division of Chemistry, Central Experimental Farm, fortnightly soil moisture determinations were made over a period of two years at depths of 1, 2, 3, 4 and 6 inches in the three soil types. Although it has not been proved as yet that the variations in soils moisture found in sandy and clay soils have any direct effect of the respective infestations in these soils a general statement regarding these records might prove of interest. Under average weather conditions, that is when the samples were not taken immediately after a rain, it was found that the soil moisture determinations vary quite constantly at the different depths and in the different soils from fortnight to fortnight. Generally speaking at the lesser depths, that is in the first inch or two, less moisture is found in the clay soil than in the light. This may be due to the fact that the surface soil in heavy land bakes hard allowing the moisture to evaporate quickly while in the sandy soil the surface is usually protected by a mulch of finely pulverized dust. As the samples go deeper, however, this condition changes. At a depth of three or four inches the moisture is about equal in all soils while at five and six inches the clay samples show a considerably higher water content than do the lighter soils. Samples taken after a rain, which was avoided as much as possible but necessary sometimes during long periods of precipitation, usually showed a reversal of these conditions. In such cases the upper soil in all cases showed a higher moisture content than the lower and little difference in percentage in different parts of the field could be noticed. It may be just possible that future study will show that these differences in moisture as noted in clay and sandy soils have some bearing on the maggot population.

Hydrogen-ion Concentration.—Hydrogen-ion concentration tests were made fortnightly in the first inch of soil throughout two summers at the different points in the study field. A La Motte-Morgan soil tester was used in this work and the results were checked up and compared with the titration method by the Division of Chemistry at the Central Experimental Farm. Although the pH did not vary very markedly at the different points it was found that the sandy soil ran around 6.6. and 6.8. while the clay soil showed a pH of from 7 to 7.4. In other words the first mentioned soil was slightly acid and the clay slightly alkaline.

The question then arose as to whether this could have any influence on the onion maggot population and a test was planned with artificially prepared soils, varying in pH from strongly acid to very alkaline, to find out whether or not ovipositing flies were attracted to or repelled by any of them while seeking suitable plants on which to lay their eggs. In making these soils, ground from a garden which showed a neutral reaction to test was used as the base. Seven soils were then prepared, three on the acid side of the scale and three on the alkaline. The seventh was left in a neutral condition. The acid soils were acidified by the addition of aluminum sulphate in varying amounts and the alkaline

prepared by the addition of lime. They were then placed in deep wooden flats, 2 feet long, 10 inches wide and 6 inches deep, and seeded to onions. They were kept screened until the plants had reached a height of about two inches and were then exposed in a heavily infested onion field for a period of a month. Daily egg counts were taken on all flats and the total eggs collected were as follows:

Nature of soil	*Number of eggs*
Very acid	126
Medium acid	106
Slightly acid	105
Neutral	78
Slightly alkaline	61
Medium alkaline	26
Very alkaline	24
Pelee marsh (Ontario)	285
Jeanettes creek (Ontario)	246

These figures point very strongly to the fact that the pH of a soil does have some effect on oviposition and may in part explain why onion maggot eggs are laid so much more abundantly in light or acid soils than in clay soils showing a pH of 7.0 or over.

In connection with this experiment a test of soils from the onion marshes of western Ontario was made. These soils insofar as pH was concerned came in the range of the slightly acid as included in the above chart. The test was made for the reason that these marsh soils have long been recognized by entomological workers as supporting a very slight onion maggot population and some explanation for the conditions was needed. It was thought that possibly the marsh soils were repellent to ovipositing females which would account for the small maggot population found there. Soils from Pelee and Jeanettes creek were secured and included in the experiment. It is very interesting to note that twice as many eggs were laid in these marsh soils as in the most attractive of the artificially prepared ones, proving that the reduced infestation is not due to the repellent effect of the soils on egg-laying-females but to some other, as yet, unknown factors.

Soil Texture.—In experimental work carried on to find out in what stage of the insect's life-history the numerical reduction in heavy soils took place it was found that practically ten times as many onion maggot eggs were laid in sandy soil than in clay soil. This was checked over two seasons by counting the number of eggs on 20 plants at each point every second day. In giving this matter consideration it was thought that among other possible factors causing such a wide variation in the numbers of eggs laid, soil texture might have a very direct bearing on the question. Onion maggot adults in laying their eggs

first work the tip of their abdomen down into the surface soil surrounding an onion plant and then extrude the ovipositor and deposit their eggs. When this operation is carried on in light or sandy soil no great difficulty attaches to it but in heavier soils where the clay is frequently baked hard it would be most difficult and sometimes practically impossible, due to mechanical reasons, for the females to get their ovipositor into the ground. In studying the question of fly distribution by sweeping and fly traps it was found that the adults are practically as abundant in the clay end of the fields as in the sandy end, so that the lack of eggs in heavy soil cannot be attributed to the absence of flies in that area.

To test the effect of different types of soils on ovipositing females a series of seven blended soils containing varying amounts of clay and sand were prepared from blow sand and blue clay. The clay was first dried out and ground up into a fine dust, so that it could be easily mixed with the sand. Six soils varying by 20 per cent were then prepared, starting with pure sand and ending with pure clay. A 50-50 mixture was also blended in order that we might have a soil, to serve as more or less of a check, containing equal amounts of sand and clay. These soils were then placed in wooden flats as have already been described, seeded to onions and kept screened until the plants had reached sufficient size to be attractive to onion maggot flies. They were then placed in a heavily infested field and daily egg counts made over a period of a month. The results are given below:—

Clay	*Sand*	
100%	0%	6 eggs
80	20	6 "
60	40	42 "
50	50	105 "
40	60	36 "
20	80	16 "
0	100	14 "

Taking the 50-50 combination as an average or medium soil insofar as clay and sand are concerned it is found that almost eighteen times as many eggs were laid in it as in the soils containing 80 or 100 per cent clay. These experiments also show that pure sand is not attractive to ovipositing flies but even here over twice as many eggs were laid as in the soils rich in clay.

In 1929, an experiment was carried on in the field to find out whether flies laid more eggs in loosened soil than in tightly packed or baked soil. These experiments were run in light, medium and heavy ground. In one series of experiments eggs counts were made on plants in which the soil had been kept loosened artificially while in the other series the plants were chosen at random in parts of the field where the soil had not been disturbed. In light soils approximately 30 per cent more eggs were recovered around plants where the soil had been

kept loose while in clay almost twice as many were counted in well worked soil than where the ground was baked. These experiments were run throughout the entire season, counts being made every second day, and certainly proved that soil texture and the mechanical condition of soils had a direct bearing on the number of eggs laid.

Chemical Composition.—Chemical analyses of the soils in our study field showed that the amount of combustible matter was considerably greater in the medium and heavy soils than in the light type. This raised the question as to whether the presence or absence of humus in a soil would have an effect on the degree of infestation, particularly at the time when the flies were laying their eggs. Work carried on by Baker and Stewart (1) showed that in their experiments they found that the degree of infestation was indirectly proportional to the amount of organic matter in the soil. That is, that the percentage of combustible matter was lower in heavily infested soils than in soils where the plants were lightly attacked. This was the condition in the study field at Aylmer, where the sandy soil which supported the heavy maggot population was found to contain less humus than the clay.

To test the effect of humus in the soil as influencing ovipositing flies, a series of artificially blended soils was prepared in which the amount of combustible matter in the different samples was varied from almost nothing at one end of the series to practically one hundred per cent at the other. Blow sand was used as the humus-free "soil" and pure muck as the "soil" rich in combustible matter. These two were mixed together in variations of twenty per cent and a 50-50 combination was placed in the middle of the series. These prepared soils were placed in specially prepared flats as have been described already in this paper, seeded to onions and exposed in the field when the plants reached sufficient size to be attractive to the flies. Egg counts were made daily over a period of a month. The results are given in the following table:

Humus	*Sand*	
100%	0%	108 eggs
80	20	144 "
60	40	137 "
50	50	182 "
40	60	171 "
20	80	95 "
0	100	41 "

The results show that quite distinct preference was shown for the soils containing the average or mean mixtures of sand and humus, that is for the 60-40, 50-50 and 40-60 combinations. It would also appear that the series very

(1) 20th Rept. Que. Soc. Prot. Plants (1927-28), pp. 92-130.

rich in humus is preferred by ovipositing flies to the soils where sand constitutes over 60 per cent of the mixture. This is particularly noticeable in the pure humus and pure sand soils.

Judging by these experiments it would appear that the amount of humus in heavy soils does not have as great an effect on the infestation as was at first supposed, at any rate does not influence the flies at time of oviposition as much at was expected. The test does show, however, that very sandy soils and soils extremely rich in humus are not attractive to the females when laying their eggs. Whether or not the presence or absence of humus in a soil would have an influence on other stages of the insect and so affect the population can only be ascertained after carrying on a study of such points as larval establishment, survival, etc., as will be done at a later date.

In connection with these experiments evaporation records were taken at the ground surface over light, medium and heavy soils. In the early part of the season the evaporation was consistently less over the sandy soil than over the clay but as the season advanced the condition became reversed. These records were taken in the hope that at some later date some correlation might be made between the activity of the flies over the different soil types and the evaporation at the ground surface.

Moisture equivalent determinations of light, medium and heavy soils in the study field were made though the kindness of Mr. S. Barnes of the Divison of Field Husbandry, Experimental Farms Branch, and are given here for purposes of reference. These determinations were made from soil at depths of 0-2 and 2-4 inches:

	Light	*Intermediate*	*Heavy*
0–2″	21.64	25.39	26.33
2–4″	22.44	26.63	27.71

Meteorological records taken during the course of these experiments included maximum and minimum temperature, maximum and minimum humidity, wet and dry bulb readings, evaporation and precipitation.

SUMMARY

In studies carried on with the onion maggot it has been found that the infestation is usually light in heavy soils and severe where the ground is of a sandy nature. The reason, or reasons, for this are under investigation and certain physical factors of the soils involved have been studied in the hope of arriving at a solution of the problem. Temperature, moisture, hydrogen-ion concentration, texture and the percentage of combustible matter are some of the factors which have received attention. The temperature in the different soils was found to vary considerably in the upper layers, clay soils being 10-15 degrees higher at the surface than sandy loam and reaching a temperature high enough

to kill onion maggot eggs. Soil moisture determinations showed that in the surface soil the percentage of moisture was greater in the sandy loam than in the clay which was reversed when a depth of three inches was reached. The hydrogen-ion concentration of the different soils also varied, the clay showing a pH of about 7.2 while the sandy loam ran around 6.8. When soils varying in pH from very alkaline to very acid were prepared and tested, ovipositing females exhibited a marked preference for the latter. Soil texture, causing a baking of the upper layer in clay soils, was shown to have a marked inhibiting effect on onion maggot flies when attempting to lay their eggs which probably explains in part the lesser infestation in these soils than in sandy land. Soil analysis showed that the percentage of combustible matter was greater in clay soils than in sand. In tests with artificially prepared soils in which the amount of humus and sand was varied ovipositing flies showed a distinct preference for the 50-50 combination and chose pure humus rather than pure sand.

THE OVERWINTERING HABITS OF THE TARNISHED PLANT BUG *LYGUS PRATENSIS* LINN., IN THE OTTAWA DISTRICT

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In the Ottawa district studies have shown that the great majority of overwintering tarnished plant bugs hibernate in the refuse and debris on the floors of woodlots. In the past, studies have shown that this insect also hibernates in many different places such as in rubbish in gardens, in the weeds and grass along furrows and about the basal leaves of perennial and biennial plants such as mullein, *Verbascum thapsus* Linn.

Studies carried on in Ottawa also indicated that such areas were used for hibernation, but the numbers of insects found in such places did not seem to account for the large numbers present in the spring. The first indication which pointed to woodlots as probable hibernation quarters was the large numbers of the insect present in such areas in the very early spring. They were noted feeding on the buds of trees and shrubs, and also on spring flowers in very appreciable numbers. A previous series of counts which had been made one autumn in the leaves beneath a large hawthorn hedge had also shown an accumulation of this species in an area where it had little or no chance to breed. In following the development of this insect throughout the season it was found that it followed what might be termed a sequence of succulence in plants. In the spring perennials and biennials served as food plants, later in the season, annuals were favoured, more or less in their sequence of blooming. Thus in the late autumn golden-rod, *Solidago* sp. which was one of the few plants blooming at this time carried a very heavy population of tarnished plant bug. It was noted, however, that as the golden-rod ripened and the flowers died the bugs deserted this plant, and scattered to perennials and biennials.

Observations made in the woodlot throughout the season showed at no time any apparent massing of this species in such places. However, with the advent of autumn and the ripening of the golden-rod there then began to show an increase in the numbers present. To check up this drift into the woods, definite counts were made in the following manner: four sites, A, B, C and D, were chosen in a woodlot. Site A was situated among large maple trees about 100 yards from the edge of the woods. The underbrush consisted of a very thick stand of young maples which had smothered out all herbaceous vegetation. Here the leaves from the old and young trees were piled loosely 6″-8″ deep, due to being held by the seedlings. Site B was on the edge of the woods with a few maples, basswoods, and elms. The ground was well covered with grass and deep moss as well as some leaves, making a fairly compact cover 4″-5″ deep. Site C was 100 yards from the edge of the woods, the trees consisting of maples and

Table of counts of tarnished plant bugs made at points A, B, C and D.

	POINT																					
	A				B				C				D									
Date	♂	♀	Total ♂ + ♀	No. per Acre	♂	♀	Total ♂ + ♀	No per Acre	♂	♀	Total ♂ + ♀	No per Acre	♂	♀	Total ♂ + ♀	No per Acre	Total of all Points	Total No. per Acre all Points	No ♂	% ♂	No ♀	% ♀
October 14	17	15	32	55,756·8	4	5	5	8,712·0	9	7	16	27,898·4	2	1	3	5227·2	56	24,393·6	28	50	28	50
" 22	8	11	19	33,105·6	10	15	25	43,560·0	13	24	37	64,468·8	7	17	24	41,817·6	105	45,738	38	36·19	67	63·81
" 29	26	37	63	109,771·2	72	67	139	242,193·6	50	34	84	146,361·6	17	10	27	47,044·8	313	136,326·8	165	52·71	148	47·28
November 5	20	27	47	88·892·8	98	102	200	348,840·0	52	48	100	174,240·0	24	16	40	68,696·0	387	168,577·2	194	50·12	193	49·87
" 12	12	15	27	47,044·8	47	42	89	155,073·6	11	11	22	38,332·2	21	17	38	66,211·2	176	76,665·6	91	51·70	85	48·20
" 19	2	3	5	8,712·0	22	21	43	74,923·2	6	8	14	24,393·6	5	1	6	10,454·4	68	29,420·8	34	50	34	50

elms, the cover here consisted of sparse grass, with moss, tall weeds, asters and considerable quantities of leaves 4″-5″ deep lying fairly close to the ground. Site D was about 100 yards from the edge of the woods on an open exposed area with few trees, maples and elms. The ground covering was sparse consisting of grass, strawberry, *Fragaria sp.* and blue weed, *Echium vulgare* Linn. over loose rock, there being only a very light covering of leaves. Each site was indicative of some particular type of cover and the four sites, taken as a whole, giving a fairly good cross section of the general forest floor covering.

Weekly collections were then made from areas of 25 square feet at each of the four sites. These collections consisted of all the refuse and debris on the surface of the ground together with the first inch of soil. This material was placed in bags and taken to the laboratory. Here it was spread out thinly on a wire topped table in a small room and the room gradually heated to about 90°F. This table was placed under two large windows and as the insects emerged from the debris they were recovered at once or in some cases were taken from the windows to which they were attracted by the light. The material was watched continuously until it was thoroughly dry and warm and then worked over for any bugs which had not moved out.

The first counts were made on October 14 and the preceding table gives the recoveries of males and females from each point, the estimated numbers per acre at each point and the total numbers per acre from all points together with the estimated number per acre. In comparing the figures of numbers per acre it might be well to bear in mind that a loss of two bugs in a collection would give a difference of approximately 3500 in the projected number per acre. (See table on page 29.)

From this table it will be seen that there was a gradual building up of numbers at all points from the time the first counts were made up to the definite freeze-up which came between November 5 and 12. That this increase is due to a drift in from outside areas is shown by the fact that in the late summer the numbers breeding in this area were very limited. The reason for this massing can probably be accounted for in the following manner. As the golden-rod becomes unsuitable in the autumn there is a movement towards other food sources which at this time are the tender crown of biennials and perennials some of which are growing in association with the golden-rod. However, as the season advances and the insects become active on bright warm days, those which are first to move about are those present in the scantest types of cover, such as is provided by the basal leaves of perennials and biennials. In the course of their movements they alight in the heavier more dense cover in the woodlot and crawl in among the leaves and debris. Here they are so protected that they do not become active again due to the denser more thoroughly insulated cover not warming up so readily in the bright days. Thus throughout the entire autumn this gradual building up of population takes place in the woodlot, so that by the time the definite freeze-up comes the greater numbers of those overwintering are present in such areas.

In the two counts made following November 5 it will be noted that there is marked reduction in the numbers as from 168,577 to 29,420 recovered. This can probably be accounted for in two ways. Up to the time of definite freeze-up there would be no evidence of mortality due to the much greater numbers entering the woods than those dying. However, following the freeze-up any mortality occurring would then become evident and this would accumulate in each successive count. The other factor is the inability to recover all the bugs present in the material at this time when there is the complication of snow and ice, making the handling of the material very difficulut.

Recoveries from 450 square feet of caged material on the woodlot floor the following spring gave a population of 60,000 per acre. It has been shown in other studies that there is a 50% to 60% winter mortality in this species and if this is taken into consideration the above figure corresponds very well with the expected number per acre from the count of 168,577 made on November 5 just before the "freeze-up".

That the heavier more compact type or cover tends to hold the insects alighting there is shown by the following. At Points B and C the cover was 4-5" deep, fairly compact and here there is a continual and marked increase in the numbers present up to November 5. At point A where the cover although deep, is very loose, and with no vegetation beneath, this increase is not constant but varies, there being a reduction from October 14 to 22, a very marked increase on October 29 and then an appreciable decrease on November 5. This fluctuation indicates that there was a considerable activity on this area due to this type of cover being readily warmed up and the insects becoming active in the heat of the day. At point D although the cover was not deep it was compact and here the increase was not so marked although there was some massing of numbers evident.

In the woodlot as a whole, however, there is a steady and fairly rapid increase in population, as is shown by the figures from 24,393 on October 14 to 168,577 on November 5. In counts made in adjoining wasteland and pasture the populations were very much smaller there being only 2,000—3,000 per acre.

It is therefore quite evident that in this district woodlots in the vicinity are the chief source of infestation in the spring. This being the case it would be advisable not to plant crops which are damaged by this insect close to such areas.

THE GLADIOLUS THRIPS AND ITS CONTROL

By Alan G. Dustan, Entomological Branch, Ottawa.

The gladiolus thrips has caused very serious damage to gladioli for two seasons. The first outbreak of this insect occurred in 1930 and was followed by a second, equally as severe, in 1931. Just where it came from is a matter of conjecture but when discovered it was at once recognized as a species new to America and given the scientific name, *Taeniothrips gladioli* M. & S.

Distribution

The gladiolus thrips is widely spread over the eastern and central parts of Canada, having been recorded from Nova Scotia, New Brunswick, Quebec, Ontario and Manitoba. No definite records of the occurrence of this insect have been received from the three most westerly provinces, although rumours of its presence in Saskatchewan and Alberta have been circulated by some of the larger growers. In the United States the gladiolus thrips has been collected in eight States, all of which are situated either in the east or in the central part of that country, thus joining with the Canadian infested area to form one large more or less continuous area in which the pest is known to be present. This insect in both Canada and the United States is of extreme importance to growers of commercial or garden flowers and at the present time is seriously threatening the whole gladiolus industry.

Injury

The damage caused by this thrips is noticed on the buds and flowers, on the foliage and on the corms in winter storage. Injury to the buds and flowers is, undoubtedly, the most important. When the infestation is severe the buds are frequently so badly injured that they do not unfold, in which case a total loss of bloom over the whole field frequently occurs. Injury to buds and blossoms is caused by the feeding of both nymphs and adults upon the plant tissues. Attacked areas become bleached and dried and often turn brown. Browning of the petals is noticed particularly at the outer edge when the bud unfolds. Whole fields of gladioli have been seen where the blooms appeared burned as though scorched by fire. Foliage injury is caused chiefiy by the adults. In feeding the insects rasp the tissue and cause whitish areas to appear which coalesce and give the leaves a very typical, silvery, appearance. When thrips are abundant on the corms in storage they feed extensively on the external tissue beneath the husks and as a result the whole surface becomes rusty-brown and is covered by small, yellowish scales. These scales are the dried excrement of the insects.

Life-history and Habits

The life-history of the gladiolus thrips is briefly as follows. The insects pass the winter on the corms and are transferred to the field at the time of planting. When growth starts the thrips move up the newly formed shoots and in the early part of the summer are to be found in the leaf sheath where they feed and increase. As the weather becomes warmer the adults are to be found on the outside of the leaves where a certain amount of feeding is done. In general these insects are shade-loving and hide in protected portions of the plant. For this reason they are not often seen until very abundant. When the spike forms they are already inside in an ideal position to attack the buds and blossoms. In cases of severe infestation the unopened blooms are usually so injured that they are completely destroyed before they get a chance to unfold. At this time the thrips are most abundant beneath the bracts where the black adults and yellowish nymphs can be seen clustered together in countless numbers. Most damage to the flowers takes place at this time but even if the blooms are able to unfold the attack is continued on the petals by both the mature and immature stages. The eggs are laid in tiny slits made in the tissue by the females. In the early part of the season egg-laying takes place in the leaf sheaths while later in the summer, after the flowers appear, many eggs are deposited in the tender tissue of buds and blossoms. When the blooms disappear the thrips once more invade the stems and leaves feeding on the most delicate parts. With the approach of cold weather migration to the corms sets in and for a time the corms and surrounding soil are thickly populated. In the late autumn, however, many of the adults leave these situations and move to other places, presumably to hibernate. Just where they go has not as yet been determined, although a thorough search was made during last October and November in an effort to find this out. It is still uncertain whether or not these thrips are able to successfully pass the winter in the open. We do know, however, that many of them go into storage on the corms and are able to live over until spring beneath the husks. If the temperature of the storage cellar is sufficiently high feeding and increase continues through the winter months and the corms are considerably damaged as a result. For this reason the storing of corms at a low temperature to keep the insects in a dormant condition is strongly urged.

Host Plants

A word should be said in regard to host plants. Many growers have the opinion that the gladiolus thrips feeds and develops on a large number of different flowering plants. This is incorrect. The point was carefully studied in the Ottawa district last summer and although many different kinds of blooms were inspected the gladiolus thrips was not found feeding or breeding on any plant except gladioli. Two adults were found on an iris plant and a few specimens captured on carnations in a greenhouse but it was thought that they were

there by accident rather than by design. This question has been carefully studied in the United States and there the gladiolus thrips has been found only on three other species of plants and then only in exceedingly small numbers. We found that practically all flowers had certain thrips feeding on them but they were not the gladiolus thirps, even though in may cases they looked very much like them.

TREATMENT OF CORMS

Of the different methods of control suggested in this paper by far the most important are those dealing with the treatment of the corms in the spring. Summer treatments give some relief, but are as yet far from perfect and for this reason emphasis should be placed on freeing the corms of thrips prior to planting.

FUMIGATION

For commercial producers, with a large number of corms to treat, fumigation of the corms, rather than dipping, would probably be the most suitable in that it is quicker, saves handling and eliminates the necessity of peeling off the husks. Three fumigants have given good results, namely, a mixture of ethylene dichloride and carbon tetrachloride, calcium cyanide, and naphthalene flakes. Each will be discussed briefly.

Ethylene Dichloride and Carbon Tetrachloride.—A mixture of ethylene dichloride (75%) and carbon tetrachloride (25%) has given excellent results both in Canada and in the United States. Besides being most effective this mixture is non-poisonous to humans, non-inflammable and consequently will not explode. It is used at the rate of 14 pounds per 1000 cubic feet of space, exposing the corms for a period of 24 hours at a temperature around 70°F. After the corms are placed in a *wooden*, air-tight container or room, rolls of blotting paper, newspaper or cloth are placed on top and the correct amount of the liquid poured over these. The material could be placed in shallow pans but as it evaporates slowly the blotting paper method speeds up this process. After the fumigant is applied the container should be closed immediately and not opened until 24 hours later. It is most important not to let the temperature drop below 70°F. since the fumigant is not nearly so effective at a lower point. This work can be done with safety in the cellar or in an unused room in any dwelling house. This fumigant kills all stages of the insects including eggs.

Calcium Cyanide.—Tests with calcium cyanide carried on in the United States by Messrs. Weigel, Smith and Richardson, have given control of all stages of thrips with the exception of the eggs. These workers recommend using this material at the rate of 2½ ounces per 1000 cubic feet of space. Fumigation

should be carried on in a tight container or room, exposing the corms for 3 hours at a temperature of 60°F. or higher. Care should be taken to see that the calcium cyanide, which is a gray powder, does not come into contract with the corms, or some damage may result. As this method does not kill the eggs a second fumigation is necessary in order that the thrips hatching from eggs in the corms at the time when the first treatment was given may be killed. The timing of the second fumigation is important and depends upon the temperature of the room in which the corms have been stored. If this temperature is about 70°F. the second fumigation should be given in 10 days, if the temperature in the storage chamber is in the vicinity of 60°F. the second treatment should be delayed 14 days, if the corms are kept at a temperature below 60°F. an even longer interval between fumigations should be allowed to elapse. After each treatment the corms and the chamber should be thoroughly aired and where a large number of trays of corms are stacked in a chamber an electric fan should be run during the treatment to increase the circulation of air. The gas from calcium cyanide, as well as the material itself, is a deadly poison and in its use the utmost care should be exercised. All fumigations should be carried on in outbuildings not in dwelling houses, and signs placed on the doors to indicate that fumigation with a poisonous gas is in progress.

Naphthalene Flakes.—According to Weigel, Smith and Richardson, of the United States Bureau of Entomology, this material when intermixed with corms in a paper bag, box or barrel at the rate of 1 ounce to every 100 corms will give complete control of gladiolus thrips, including the eggs. The corms should be exposed to the fumes of the naphthalene for a period of 2 or 3 weeks at a temperature of around 60°F. No injury to the corms took place even after an exposure of 6 weeks at this concentration. Care must be exercised to avoid placing the corms in too tight a container, such as a tin can, since over such a long period of time the moisture collecting in the container will induce sprouting. This method, although it has not been tested by the writer shows decided promise, and should be cheap and very easy to apply.

DIPS OR BATHS

The grower, with only a few corms to treat, will probably find one of the following dips more simple and easier to adopt than any of the fumigation methods mentioned above. They are just as effective in so far as the control of thrips is concerned and are, in general, equally cheap or cheaper.

Corrosive Sublimate.—Additional work with this material has been carried on and good results secured where the corms, after peeling, were dipped for 3 hours in a solution made up of 1 ounce of corrosive sublimate dissolved in 6 gallons of water, at a temperature of 70°F. All stages of the thrips, including the eggs, were killed by this treatment. In our experiments it was found that the

peeling of the corms was essential if perfect control was to result. Corrosive sublimate should be mixed and placed only in wooden, earthenware, enamel or glass vessels, since it quickly corrodes metals. The material should be dissolved in a small amount of hot water and then diluted to the correct strength. As this is a deadly poison the greatest care should be exercised in its use.

Hot Water.--In tests carried on at Ottawa and elsewhere it has been found that all stages of the thrips, including the eggs, are killed by dipping the corms in hot water at a temperature of 120°F. for a period of 10 minutes. With this method it appears to be immaterial whether the corms are peeled or not, since excellent results were secured with both peeled and unpeeled corms. The temperature of the bath should be kept up to 120°F. for the entire period. This can be done by adding small quantities of hot water to the bath from time to time. Care must be taken not to allow the temperature to go over 120°F. as injury to the corms may result.

Whale Oil Soap.—A bath composed of whale oil soap, using 1 pound to 4 gallons of water kills all stages of thrips, except the eggs. It is recommended that where possible the corms should first be peeled and then soaked in the liquid for a period of 3 hours at a temperature of 70°F. Since the eggs are not killed by the dip a second treatment will be necessary to kill the young thrips which will hatch later. In computing the time for the second treatment, the directions given under the calcium cyanide method should be followed. Whale oil soap can be purchased through all seed houses and is sometimes carried by the larger hardware stores.

SPRAYING AND DUSTING IN THE FIELD

Extensive spraying and dusting experiments were conducted at Vineland and Ottawa during the past summer by Mr. P. I. Bryce and the writer with a view to finding an effective control in the field. Such sprays as lime sulphur, nicotine sulphate, pyrethrum extracts, derris extracts and Paris green and brown sugar, etc., were tried. Applications of nicotine sulphate, pyrethrum, and hydrated lime, in dust form were also made. The results in most cases were disappointing as it was found that although the thrips which were present on the outside of the plants were killed those concealed in the inaccessible parts were uninjured. The best control was secured where the plants were sprayed with a mixture made up of Paris green 2 table spoonfuls, brown sugar 2 pounds and water 3 gallons. Spraying should commence as soon as the thrips are found inside the leaves and should be continued weekly while the insects are present. Washing off the plants from time to time with a spray of cold water is beneficial as it removes the residue left by the brown sugar. The spray should be stirred continually when being applied as the Paris green sinks to the bottom of the

pail quickly, due to its weight. Spray thoroughly at a good pressure, using plenty of material at each application.

Fumigation in the Field:—Fumigation of small numbers of gladioli (with calcium cyanide) under oilcloth or brown paper tents gave excellent control in experiments carried on in the field last summer. The method, of course, would be suitable for small gardens only or for growers having a few prized blooms which they particularly wished to protect. The work was carried on in a long A-shaped tent, having a light wooden framework covered with brown paper which was made tight at the joints by means of mucilage. The tent was built sufficiently large to completely cover a section of row, without rubbing the tops of the plants. The best grade of calcium cyanide was used and at the rate of six ounces per 1000 cubic feet of space. Fumigation tests were made on abright, warm day when the temperature inside the tent registered about 75°F. and were commenced as soon as the first thrips was seen. Exposures of one hour gave best results.

Care of Corms at Harvest: - In the autumn when the corms are being harvested they should be given special attention to safeguard them from the invasion of thrips. The tops should be cut off as near the corm as possible, since many thrips are present on the leaves and stems and will migrate on to the corms if the opportunity is given. When pulled, the corms should be removed immediately from the field to a place where there is no danger of infestation by the thrips moving to them from the tops. They can be dried there and then placed in storage. If at all possible the corms should be stored in a cellar or building where the temperature can be kept down as low as 40°F. This is most important if the thrips are to be kept in a dormant condition. If the temperature is much higher, feeding and development will continue through the winter and injury to the corms result.

All tops should be burned as soon as cut. This step is most important as many thrips will be destroyed if this is carefully done. Plough or dig up the bed in the late fall, thus exposing any thrips which may be overwintering there.

TECHNIQUE AND METHODS IN THE STUDY OF CLIMATIC FACTORS IN CONNECTION WITH BIOLOGICAL INVESTIGATIONS

By J. J. de Gryse

The study of the influence of climate upon insects offers a wide field for speculation as well as experimentation. The present paper is concerned mainly with the latter, more especially with certain very elementary points of technique and methods of analysis. No claim whatsoever is laid to originality, the main object of the dissertation consisting merely in bringing together in condensed form a few of the most essential facts which should be known to every one intending to make observations on the relation of weather and climate to insect behaviour and development. Whilst minimizing in no way the fundamental importance of laboratory experiments, this paper is restricted to the discussion of field observations, mainly because the time allotted for it is barely sufficient to treat in the most sketchy fashion this particular phase of the subject, and also because facilities for exact laboratory experiments are, at the present time, not available to the average entomologist. A more or less satisfactory treatment of the subject matter should include two parts or sections, namely, meteorological observations and biological studies. Originally, it was my intention to consider both, but, I soon discovered that the meteorological side of the question alone presented more material than could be adequately elaborated. This paper, then, is, of necessity, exceedingly incomplete and imperfect, but it is hoped that it contains a number of suggestions that may be of some value to prospective students of climate in its relation to insect life.

Roughly speaking, a record of meteorological data, to be of any value to the biologist, should possess three principal qualifications, it should be first of all accurate, it should also be as complete as possible and, finally, it should be comparable to other similar records and also to the biological record with which it is to be correlated. Each of these qualifications is treated separately in the following.

ACCURACY

The accuracy of a weather record depends almost entirely on the quality of the instruments used and upon the observer's knowledge of their action, their manipulation, their sources of error and the method of making the necessary corrections. Under this heading, therefore, we shall discuss briefly the subject of instruments and their use in the measurement of temperature, humidity, light, wind, pressure and evaporation. Several of the instruments described below will probably never be used by the average worker. They are mentioned because a general idea of the principles underlying their use and operation will often

give a better understanding of the instruments more commonly employed in making ordinary observations.

THE MEASUREMENT OF TEMPERATURES

Temperature is the physical measure of that condition of a body which enables it to produce the sensation of heat or cold. The measured difference of degree in which this condition exists is the difference in temperature and may be defined by any one of the physical changes accompanying any variation in condition. Instruments designed for this purpose are known as thermometers or pyrometers.

(1) **The Standard Thermometer.** (Constant Volume Gas Thermometer).

It is evident that in measuring the effect of temperature either upon the same property in different bodies or upon different properties in the same body, the results obtained will differ very greatly. To avoid confusion arising from such differences, a specific property of a definite substance has been chosen as a basic measurement or standard to which all other thermometric measures may be compared. In constructing such a "standard thermometer", it has been agreed to choose the effect of temperature upon the pressure of hydrogen gas enclosed in a vessel of constant volume. In other words, in such a thermometer a change of temperature is expressed or measured in terms of a corresponding change in pressure. The dry gas is enclosed in a suitable vessel which is connected by a capillary tube to a U-shaped manometer. The gas is shut off from the outer air by the mercury in the U-tube. The gas is kept at constant volume by keeping the mercury at constant level in that part of the manometer to which the capillary tube is attached. The pressure to which the gas is subjected is found from the barometric pressure and the difference in level of the mercury on the two sides of the manometer. The readings obtained from such a thermometer will be discussed in the paragraph on thermometric scales.

Other effects of temperature are used as basis for measurements, such as the change of volume of a gas under constant pressure (constant pressure gas thermometer), the expansion of mercury in glass (mercury-in-glass thermometer) etc. These thermometers will agree closely with the constant volume hydrogen thermometer, but in very exact experiments a reduction to the latter is always necessary.

(2) **Temperature Scales**

The instrument commonly used in measuring temperatures is the mercury-in-glass thermometer. The unit of measurement is the degree. The value of the degree varies with the scale used.

(*a*) The scale ordinarily used in scientific work is known as the Centigrade scale. One degree centigrade is 1/100 part of the interval between the tempera-

ture of melting ice and the temperature of boiling water under normal pressure (76 cm). These points, known respectively as O and 100°C., are the "fixed points" of the scale and the interval between them is usually designated as the "fundamental interval."

The centigrade scale was first developed by Celsius in 1742. Celsius' O was the boiling point and his 100° was the freezing point. It was Linnaeus who suggested that O be used as freezing point and 100° as boiling point.

(*b*) The Fahrenheit scale is older than the Centigrade scale. It was introduced by Fahrenheit in 1714. In this scale 32° is the freezing point and 212° the boiling point. To reduce the reading of F to C or *vice versa*, the following proportion is used.

$$\frac{F - 32}{180} = \frac{C}{100}$$

In other words, the readings are referred to the same temperature, namely, the melting point.

$$180C = {}^{100}(F - 32)$$

Hence $$C = \frac{100\ (F-32)}{180} = \frac{5\ (F-32)}{9} = .56\ (F-32)$$

$$\therefore \quad F - 32 = \frac{180C}{100} = \frac{9\ C}{5} = 1.8C$$

Fahrenheit himself did not use the freezing and boiling points as fixed points but the temperature of a mixture of water, ice and sal ammoniac which is his zero and the temperature of blood which he designated as 96.

(*c*) The Reaumur scale is no longer in use. In it the fundamental interval is divided into 80 degrees.

(*d*) The absolute scale.—In recent years the absolute scale or Kelvin scale is gradually superseding the above-mentioned scales in meteorological work. In the three first mentioned scales, the fixed points are the freezing and boiling points of water. On the absolute scale, there is only one fixed point, the absolute zero. This corresponds to 273.02°C. The absolute scale is the gas-thermometric scale. Its zero is supposed to be the absolute zero of nature, namely the point at which hydrogen gas will exert no pressure because all molecular motion ceases, which amounts to the same thing as saying that the gas contains no heat energy. The assumption is that hydrogen will remain as gas even at the lowest temperatures, but this assumption is not in accord with fact, hydrogen having been liquified and even frozen at very low temperatures. The great advantage of the gas-thermometric or absolute scale is that it contains no negative values. The absolute scale is divided into degrees equivalent to either Centigrade or Fahrenheit. A certain amount of confusion is apt to arise from this particular feature.

(3) Mercurial thermometers

The first thermometer was probably invented by Galileo about 1590. Until the time of Fahrenheit various liquids were used in the construction of thermometers. Boullieau in 1659 was the first to use mercury, but great improvements were made by Fahrenheit in 1774. The principle of temperature measurement by means of the mercury-in-glass thermometer, is based upon the definition that a temperature change is proportional to the apparent increase in volume of mercury. This apparent increase is the difference between the actual change in the volume of mercury and that of the containing vessel. From this it may be seen that perfect agreement between the standard hydrogen thermometer and the mercury thermometers must not be expected. It should further be remembered that "glass" is not a well defined chemical substance and that thermometers made of different kinds of glass will not agree among themselves.

It may be useful to say something about the construction of thermometers. Thermometers are made of wedge-shaped tubing. The convex surface of the wedge has an enameled surface. When the tube is drawn into thermometer stems, the pointed edge of the wedge becomes rounded and acts as a lens which magnifies the capillary duct through which the mercury rises in the stem, thus facilitating the reading of the instrument. The white enamel backing helps to bring out the graduations engraved on the stem. In ordinary thermometers, the bulb is blown at the end of the tube and hence is of the same material as the tube. In better thermometers, the bulb is made of special glass and is fused to the end of the stem.

One of the principal sources of error in thermometers is caused by what is known as "hysteresis." Hysteresis is a protracted process of molecular change consequent upon heating solids to high temperatures. This change may last over long periods. It results in slow contraction of both bulb and stem in thermometers, affecting the size of the bulb and the diameter of the bore in the stem. Hence, the zero point is raised in the instrument. This error may amount to as much as 6°F. In good thermometers this error is overcome by "seasoning" or "tempering". This consists in laying away the tubes for a period of two years. It is said that some of the changes to which glass is subject may be overcome if the glass is maintained at 400°C for a considerable time.

Cylindrical bulbs are preferable to spherical bulbs, because, having a greater surface, they are more sensitive. The bulb is filled by heating and thus expanding the air contained in it. Whilst the bulb is hot, the open part of the stem is plunged in mercury. When the air cools, it contracts and an amount of mercury enters the stem. The process is repeated until the stem is full. After the filling, the thermometer is "roasted" for a few hours to expel any moisture that may be present. Before the tube is finally sealed, the bulb is first heated until the mercury column reaches the top of the stem.

The graduation is accomplished in several stages. The thermometer is first placed in brine at 20°F., then in melting ice at 32°F., and finally in waterbaths

at 62°F. and at 92°F. The position of the mercury column is marked for each of these temperatures. Further divisions are then made with ruling machines.

There are many grades of thermometers and for the most part these may be recognized at once. As Geddes says, "a bad thermometer is worse than none." Hence in selecting a thermometer, certain points should be considered. The name of the maker is one of the first of these. By name is meant not only the "reputation" but the actual placing of the name of the manufacturer on the instrument. As a rule (*though not always*) reliable manufacturers do not put their names on low-grade instruments. A thermometer without name is nearly always a "reject." First class thermometers may be recognized by two means, either they have small marks (arrows or diamonds) engraved upon the scale at the testing temperatures, or they are accompanied by a certificate and corrections for every tenth degree of the scale. Only such instruments should be used in meteorological work.

In purchasing a thermometer, the range of the scale must next be considered. The scale must be adapted to the temperatures to which the instrument is likely to be exposed. When very low temperatures are to be measured (below 39°C.) alcoholic thermometers must be used. The graduations should be marked on the stem (not simply on the backing to which the thermometer is attached.)

From what has been said, we may go further and conclude that even the best thermometers may not always be equally reliable and that, at intervals, they should be tested by comparison with standard instruments.

In the use of a thermometer one should be equally as careful as in its purchase. Several significant errors may result from faulty usage. (1) In taking a reading, the observer should stand squarely in front of the end of the mercury column and thus avoid what is known as error of parallax, or error due to perspective, which may amount easily to as much as 1°. (2) Observations must be made quickly to avoid error due to temperature of the body of the observer. (3) If a thermometer is moved from one place to another, where temperatures are considerably different, at least 5 minutes should be allowed to elapse before a reading is taken. Thermometers, if they are very sensitive, will give different readings in a horizontal position from those in a vertical position on account of the hydrostatic pressure of mercury. (4) Thermometers subjected suddenly to great changes in temperature may become "strained" and permanently impaired thereby.

Attention might be called also to what is known as "thermometer lag." All thermometers exhibit a lag, hence when a reading is taken, sufficient time should be allowed for compensation of this lag. This lag is different in different instruments and depends upon the shape of the bulb, the thickness of the glass, etc., etc.

The question of comparison of thermometers with standards arises here. There are several ways of standardizing thermometers. The simplest one con-

sists in comparison with a thermometer whose readings are known in relation to the International Temperature scale. Methods and apparatus for doing this have been worked out in detail by Physical laboratories and it is to them that we must go for this work. It cannot be satisfactorily done by the layman.

(4) The Measurement of the Temperature of the Air

(*a*) **True air temperatures.**—The measurement of true air temperatures is a matter of considerable difficulty, in fact it is one of the most difficult of meteorological measurements. The trouble arises from the difference in the effects of radiation upon the air and upon the materials of which the thermometer is constructed. The air, especially when it is dry, is diathermous to radiant heat, that is, radiation from the sun, clouds, earth or surrounding objects pass through it without noticeably affecting its temperature. The thermometer, on the other hand, absorbs radiant heat. It is a well known property of glass that while it allows the short light waves of radiation to pass through it, it forms an obstacle to the passage of long heat rays. As a result, the heat received from the light rays becomes, so to speak, imprisoned in the bulb and can only be lost to the surrounding air by conduction. Since the air is a bad conductor the heat will escape very slowly and upon continued exposure to the effects of radiation, heat will accumulate in the bulb to such an extent as to raise its temperature very considerably above that of the surrounding air. Under certain conditions, the difference may amount to 50°F. and more. There are three principal ways of overcoming this difficulty, the sling thermometer, the Assmann aspirator thermometer and the thermometer shelter. These will be discussed now.

The sling thermometer

This is a thermometer mounted on a whirling device—(the dry bulb thermometer of the sling psychrometer serves the purpose). It is a most convenient and a most reliable simple instrument for measuring true air temperature, and as such it is most valuable in checking the accuracy of the records of other instruments, such as those exposed in shelters. It is important, therefore, that its operation be understood. In the general notes on "true air temperatures" just preceding this paragraph, it has been shown that the chief source of error in measuring air temperature, is the effect of radiation. Radiated heat intercepted by the thermometer bulb and imprisoned in it must be lost by conduction. The principle upon which the operation of the sling thermometer is based consists in equalizing the effects of radiation and conduction. Since the effect of radiation is in excess of that of conduction, the effect of the latter must be increased. This is accomplished by bringing the thermometer bulb in contact with a large quantity of air by whirling it. It is self-evident that such an operation will be most successful under conditions of least radiation, since the effect to be overcome is less. Hence, it is advantageous to perform the operation in the shade. However,

this is not absolutely necessary, since it has been found that true air temperature can be measured in bright sunshine to one-half degree Fahrenheit, provided the reading be quickly made. Theoretically, at least, the sling thermometer is subject to two principal errors, the one causing depression by centrifugal force, the other, causing elevation by friction. Since these errors are in opposite directions, they tend to counter-balance each other and are regarded as negligible.

The Assmann aspirator thermometer

It has been found that the Assmann aspirator thermometer is accurate to 1/10°F. under any condition. The instrument consists essentially of a thermometer encased in a double coaxial heavy metal tube, through which air is drawn past the bulb by means of a fan mounted in the top of the instrument. The casing excludes radiation and the velocity of current passing the bulb is never less than 2 metres per second. Such instruments, like the sling thermometer, are usually provided with two thermometers (dry and wet bulb) for the measurement of humidity as well as of temperature.

The thermometer screen

We may repeat here that the object of the thermometer screen or shelter is primarily the exclusion of all radiation. The screen serves a further purpose by protecting the instruments exposed in it from the weather, especially moisture in the form of rain or snow. The requirements of a good screen are therefore, that it accomplish both purposes and at the same time that the conditions of the air inside of it be the same as those of the surrounding air. There are many types of such screens in use in different parts of the world. Among these we merely mention the Sainte Claire Deville Screen used largely in France, the Glaisher screen (England), the tropical screen, the Stevenson screen.

The latter is the standard screen in this country. It was designed in 1866 by Thomas Stevenson of Edinburgh. In later years it has been variously modified, but in its general plan it remains very similar to the original. The Stevenson screen is a box with a double roof. The outside roof is made of solid planks and slopes toward the rear of the box, the inside roof is horizontal and has a number of holes drilled through it. These two roofs are separated by an air space of about 1½ or 2 inches. The four sides of the box are double-louvered. The front side is hinged at the bottom of the box and serves as a door. The thermometers are mounted on vertical wooden supports in the middle of the box. The inside dimensions are 18 x 11 x 15 inches in the standard screen. However, the box may be made in any dimensions according to the requirements of the observer. The bottom of the box consists of three planks so arranged as to be about 1 inch one above the other and so as to overlap each other by about one inch. The screen is placed on an elevated platform

with the bottom about 3½ feet from the ground and with the door facing north.

The object of the whole construction is to exclude radiation and weather and to admit as free a circulation of air as possible. Both these ends are only imperfectly attained. Numerous experiments show conclusively that under certain circumstances, as on hot sunny days, the temperatures recorded in such a screen may be 2° or 3° Fahrenheit above the temperature of the surrounding air and that on cold clear nights they may fall below the true temperature by as much as a whole degree. Again on calm days, pockets seem to form in the shelter and as many as four or five different temperatures may be found in different parts of the screen.

Usually it is recommended that such screens be placed away from the influence of buildings or trees. The general rule is that the shelter should be distant twice the height of an object. Some observers, however, see no objection to placing the screens near trees provided they are removed from the trunks and branches by a distance of about 8 feet.

It is clear, that for accurate results, the temperatures registered in the screens should be frequently checked by means of the sling thermometer.

(*b*) **Thermometers used in measuring maximum and minimum temperatures.**

Maximum thermometers

In maximum thermometers there is a slight constriction in the bore just above the bulb, this prevents the backflow of mercury from the stem to the bulb. Hence the column of mercury in the bore will always indicate the highest temperature since the previous setting. The hour of maximum temperatures usually occurs between 2.30 and 4 p. m. Therefore, maximum thermometers should be set either early in the morning or late in the evening. The setting of a maximum thermometer is accomplished by swinging it sharply with the bulb downward. Some thermometers are mounted on pivots and in this case the setting is done by whirling the instrument on the pivot. The thermometer is properly set when it gives the proper reading of the air temperature at the time of setting. This is sometimes referred to as the "set temperature". In books it is often recommended to compare the "set temperature" to the temperature of an ordinary thermometer or to the actual temperature of the minimum thermometer hung in the shelter. This, however, is not always satisfactory. The swinging of the maximum thermometer during the act of setting is comparable in its effect to what happens in the ordinary sling thermometer. Therefore, unless the instruments in the shelter indicate "true air" temperature, they do not constitute a reliable criterion by which adjustment of the maximum thermometer can be made. As a matter of fact, in the majority of cases there will be a discrepancy between the "set maximum" and the actual temperature showing on the minimum thermometer. There is, moreover,

another possible cause of discrepancy inherent to the construction of minimum thermometers. This will be explained in the paragraph on minimum thermometers. In practice, one soon becomes acquainted with these apparent abnormalities and knows how to allow for them.

The principal source of error in the maximum thermometer is due to "retreating", that is, backflow of mercury into the bulb. Some thermometers are regularly defective in this respect and are known as "retreaters", in others retreating occurs only occasionally. A regular "retreater" should be returned to the manufacturer. Occasional retreating can be prevented by hanging the maximum thermometer in such a way that the bulb be slightly higher than the stem.

Unless the instrument is handled gently and with care, retreating is most apt to take place at the time of reading. To make the reading, it is necessary to raise the stem of the thermometer in such a way as to cause the column to come in contact with the constriction above the bulb. The greatest care should be exercised in performing this operation, especially if, from experience it is known that the instrument is easily set. This brings up the question of choice in the purchase of maximum thermometers. It is a well-known fact that some makes of maximum thermometers require a considerable amount of vigorous swinging in setting, while others are very easily brought to the "set temperature". It would seem that, for reliable results, a thermometer requiring a medium amount of whirling is the best type, and that thermometers which are easily set cannot be regarded as trustworthy. A well made maximum thermometer is a very satisfactory instrument and seldom gets out of order.

Minimum Thermometers

The minimum thermometer is nothing more than an ordinary alcohol thermometer in which a dark blue glass index, in the form of a long dumb-bell is immersed. The instrument is mounted horizontally. When the temperature rises, the alcohol flows freely past the index which remains stationary. When the temperature falls, the index is not affected by the flow of the liquid until the meniscus comes in contact with the end of the "dumb-bell", when, upon further retraction the index is carried toward the bulb by virtue of surface tension at the free end of the alcohol. The thermometer, therefore, will indicate the minimum temperature of a period, by the reading at the end of the index farthest removed from the bulb.—The instrument is set by raising the bulb and allowing the index to float downward until it reaches the end of the spirit column.

Minimum thermometers when received from the manufacturer, are nearly always out of order. In the course of transportation, the alcohol column becomes disrupted, a number of bubbles appear in the bore or some alcohol may be lodged in the small chamber at the end of the stem. To remedy this condition, grasp the thermometer at the upper end of the stem and swing

the instrument vigorously as though it were a hammer, taking care, of course, not to strike any object. This operation sometimes requires vigorous exercise and a considerable amount of time. Ultimately, however, centrifugal force will bring the parts of the broken column in contact with each other. If this fails, place several thicknesses of soft paper on a table, grasp the instrument near the bulb and strike the paper with the hand. Whilst, a certain amount of care must be exercised to avoid breaking the instrument, considerable force may be used. Instead of striking the paper with the hand, the instrument may be allowed to fall an inch or more so that either the backing or the guard strikes the paper. In all cases, the bore of the instrument should be examined very carefully, especially the small chamber at the end of the stem, to make certain that no alcohol remains in the upper end of the tube. Once the column is joined, the instrument should be placed vertically, bulb-end downward, and should remain in this position for an hour or more.

If the index is stuck in the farther end of the tube, it may be dislodged by tapping the edge of the backing with a small piece of wood. When free, it may be driven into the alcohol by centrifugal force by a few vigorous swings. Patience and perseverance are the requisites in all the above described operations. Some instruments will be found which refuse to function properly under any circumstances, these should be returned to the manufacturer.

The introduction of the index into the spirit column, necessitates the use of a larger bore in minimum thermometers than in those of any other type. The openness of the scale is only slightly affected thereby, the coefficient of expansion of alcohol being nearly six times that of mercury. There is, however, a decrease in sensitivity in minimum thermometers and this should be taken into consideration when comparisons are made with other thermometers.

Possibly the most important defect of minimum thermometers is due to evaporation of the alcohol. Alcohol evaporated from the end of the column will settle and condense in the space at the end of the tube and there form a bubble, sometimes several degrees in length. The separation of such bubbles appears to occur most frequently on days when the temperature range is very great. Even when no bubble is apparent, a very thin film of alcohol may be spread over the surface of the bore and this may cause, at times, errors amounting to as much as 1°F.

Finally, in making minimum thermometers, the tube is sealed whilst the bulb is immersed in a freezing mixture. In this way as much air as possible is included in the tube. By this process, the chances for diffusion of vapour, described above, are lessened and the defect is somewhat corrected. On the other hand a new source of error may be introduced. We know that in making a mercurial thermometer, it is the practice to seal the stems while the mercury is heated so as to fill the column completely. As a result, a vacuum is created above the mercurial column and the pressure inside the bore is less than that of the atmosphere. In the minimum thermometer, the pressure is greater,

hence the action of the instrument is retarded. Moreover, it has been found that, sometimes, the excess pressure in the minimum thermometer causes enlargement of the bulb and thereby a proportional reduction in the readings. This explains why such thermometers are usually found to require positive corrections upon being tested. Here again, we must repeat what has been said above and what applies generally in the case of instruments used for measurements of any kind, sufficiently frequent standardization will prevent many costly errors.

Six type thermometers

The Six thermometer, is a convenient form of maximum and minimum thermometer combined in a single instrument. It is cheap, easily manipulated and quite proof against breakage. Where accuracy is not particularly aimed at, it may be useful provided it be well constructed.

The tube is bent in three sections. The bulb is at one extremity in the centre of the instrument. It is long, cylindrical. Another oval bulb, about 1 cc. in volume, is found at the other end. The U part of the tube is filled with mercury. The central bulb is completely filled with either creosote or alcohol, the end bulb is partly filled with the same liquid and above the liquid there is an air chamber. When the temperature rises, the liquid in the central bulb expands and pushes the mercury column downwards in the left side of the U tube and upwards in the right side. This naturally, compresses the air contained in the upper bulb. When the temperature falls the reverse action takes place in all parts of the thermometer. Small indices, held up by feather springs in each side of the U tube, register all the movements of the mercury column. As a result, minimum temperatures may be read on the left side and maximum temperatures on the right side by noting the position of the lower end of the indices on the scale. The scale reads downwards on the left and upward on the right. The thermometer may be set by means of a magnet which brings the indices in contract with the end of the mercury column.

One of the principal defects of the Six thermometers is the inequality in the mercury column on either side of the U tube. When a Six thermometer has been lying on its side for a considerable time—for instance in transit—it not infrequently happens that a part of the alcohol or creosote from one bulb flows past the mercury to the other bulb. Therefore, the readings on both sides do not coincide. This condition cannot be corrected except by an expert. If the error is small, however, a correction can be applied to the readings without great inconvenience to the observer.

It is generally conceded that the majority of Six thermometers are sluggish and inaccurate and that they should not be used in scientific investigations where accuracy is a prime requisite.

Recording thermometers

There are several types of recording thermometers or thermographs. They may be divided according to their method of registration into two classes *a*) thermometers with photographic registration and *b*) thermometers with mechanical registration.

The photographic recording thermometer, also called sometimes the telethermometer, consists of a long glass tube with two right angle bends (this arrangement enables exposure of bulbs outside of buildings) filled with mercury. In the mercury column at a certain point there is a small break or air bubble. Two lamps are focused on that part of the thermometer where the temperature differences are registered. Behind the mercury column, in a dark chamber, there is a revolving drum carrying a sheet of photographic paper. As the air bubble rises or falls with the temperature, light from the lamps passing through it affects the photographic paper and traces the record. Every hour or every two hours the light is shut off for four minutes and convenient time marks are thus provided for the recording of the charts.

Such thermometers are in use in observatories only. Their great advantage is that mechanical means of recording and hence all friction are eliminated. Their disadvantages are that no readings can be made until the records are developed and that the sensitive elements or bulbs are of large proportions and thus cause sluggishness in the instrument.

Another type of mercurial recording thermometer is adapted for mechanical registration. The mercury is contained in a steel tube connected by means of a flexible steel pipe to a box with a corrugated diaphragm of the same material. Expansion or contraction of the mercury with rising or falling temperature raises or lowers the diaphragm. These movements magnified by a system of levers is recorded in the usual manner upon a revolving dial or drum carrying a graduated chart.

Possibly the most commonly used recording instrument is the bi-metallic thermograph. The record is made, as in the previous instruments, on a clock-driven drum carrying a graduated chart. The sensitive element is a long strip of two pieces of brass and invar electrically welded together and coiled in the form of a spiral. The brass is on the inside and the invar on the outside of the coil. One end of the coil is fixed to the frame, the other is connected through the horizontal axis to the arm which carries the pen or to a system of levers operating this arm. Changes in temperature cause the lengthening or shortening of the strip, the difference in the expansion coefficients between brass and invar produces a coiling or uncoiling of the element. The pen and levers are adjusted so as to transcribe these movements in thermometric values on the record chart.

Instruments of this kind should be frequently checked with the sling thermometer and the necessary adjustments made. Some observers recommend checking three times daily. The necessity for this operation will depend

largely upon the performance of the individual instrument. With some instruments it may be sufficient to verify the readings once a day. After the instrument has been in operation satisfactorily for a few days, one of the simplest methods of checking the readings consists in comparing them with those of a maximum and minimum thermometer exposed in the same shelter, with its bulbs as close as possible to the sensitive element of the recording thermometer. The minimum temperature furnishes the most reliable datum for this purpose. Compare the value of the minimum on the thermograph with that of the minimum thermometer then adjust the pen for the difference between these two. It is often advisable to make the adjustment slightly less than the discrepancy. There are two principal sources of error (1) The wrong adjustment of the pen (2) Expansion or contraction of the chart. Whenever a correction is made its positive or negative value should be indicated on the record chart at the time of correction.

When the sling thermometer is used for checking a thermograph, it should be remembered that the thermograph is sluggish and that there may be a lag that may amount from five to forty-five minutes. Hence the record is more or less an average for the temperatures registered during the period of lag. In comparing a sling thermometer to such a recording thermometer it is, therefore, necessary to compare the average of a number of readings taken at intervals on the sling thermometer to the temperature on the chart, rather than the actual reading obtained from any one observation. The lag in the thermograph is usually greatest in damp weather. In such weather, the record chart will expand or swell more than at other times, this may render the record of the maximum 2 or 3 degrees too low. Hence, especially on damp days, the maximum should be compared as well as the minimum and the necessary corrections indicated on the chart.

The Bourdon thermograph depends upon increase or decrease in the curvature of a metal tube with varying temperatures. The tube, in cross-section is a very flat ellipse, in longitudinal section it has the form of a quadrant of a circle. One end of the tube is attached firmly to frame, the other end is free and actuates a system of levers and a recording pen. Expansions and contractions of the alcohol with which the tube is filled govern the above mentioned changes in the curvature and the corresponding movements of the tube when they are imparted to the recording mechanism and thus introduces error due to friction, moreover, the instrument in itself is less sensitive than the bi-metallic thermometer.

Electrical recording thermometers are merely mentioned here. They are not used extensively in meteorology. They are essentially resistance thermometers equipped with a Callendar electrical recorder, which is a self balancing and recording Wheatstone bridge, in which two of the resistance arms are equal to each other. (The subject of electrical thermometers will be treated in a separate chapter.)

(5) The Measurement of Soil Temperatures

The measurement of soil temperatures relates to either current temperatures or to temperature ranges (max. and min. temperatures.)

(*a*) Measurement of current temperatures. This is accomplished by means of the so-called standard soil thermometers. There are several types of these.

One type consists of a sluggish thermometer attached to a chain. This thermometer is let down into the ground to the required depth inside of a metal tube of slightly larger diameter than the thermometer stem. The tube is closed with a cover to which the chain is attached. Sluggish thermometers are used because with reasonable precaution they make it possible to read the soil temperatures after withdrawal of the instrument without danger of its being affected by the temperature of the air in the open. Sluggishness is obtained by the use of thick glass and large bulbs or by enclosing the thermometer in a sealed glass tube with the bulb immersed in paraffin wax. In some thermometers, the scale is exposed above the ground. The bulb is protected by a pointed steel guard which may be driven into the soil to the required depth. Such thermometers, unless protected from radiation, may require "emergent stem correction".

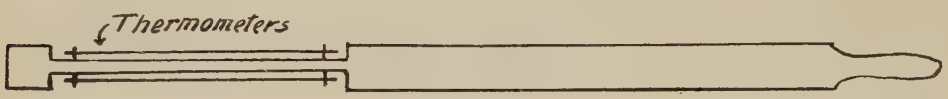
Right-angle soil thermometers are used extensively by investigators. They are essentially long-stem thermometers the tube of which is bent at right angles at a measured distance from the bulb. The bend occurs at a distance from the bulb equal to the depth at which it is desired to obtain temperature readings. Ordinarily such thermometers are made to measure temperatures at depths of about 6 to 12 inches. When the bulb is inserted into the earth at the proper depth, the scale lies horizontally on top of the ground, the thermometer bulb is lowered into the hole and then the space surrounding the bulb and the buried part of the stem may be filled with sand. It would seem that such thermometers, as well as those of the type first described will require "emergent stem correction," especially under certain conditions of exposure. It would probably be advisable to cover the exposed part of the stem with some insulating material.

(*b*) Measurement of maximum and minimum temperatures. The method of measuring maximum and minimum temperatures in the soil most commonly used consists in exposing appropriate thermometers in bottomless boxes, sunk at the required depths. Experiments have shown that this procedure is mostly unsatisfactory and subject to considerable error. A similar method, sometimes used, is to expose the thermometers in underground chambers dug in the soil, lined with wire screening and covered with a wooden lid and debris. This method is open to the same objections as the one described above.

Probably the most satisfactory device known to date is the soil well method proposed by Toumey and Stickel in "Ecology", Vol. VI, No. 2, 1925. The following description is taken from the original article on this subject:

"The following is believed to be a more acceptable method for using standard maximum and minimum thermometers in soil temperature studies. By this method readings can be taken at various depths without disturbing the soil and vegetation above the location of the instruments. Furthermore, the instruments are not exposed in a large air space but in close contact with the soil.

"A soil well is excavated 1½ feet wide by 5 feet long and to the required depth. A framework of wood is placed in the excavation upon which rests a double cover with a three inch air space between. These covers, when in place, completely enclose the well and are removed when readings are taken. One end of the well is faced with boards with openings at the depths at which temperatures are to be taken. A two inch soil augur is used to make the borings at these openings parallel with the surface and to a distance of two or three feet from the well. A special device (see figure 1) with standard maximum and



(Fig. 1)

minimum thermometers attached, is inserted in each boring at the depth desired. The device, which is made of wood, is slightly less in diameter than the boring. A bit of cotton wrapped about the device, at the point of contact with the soil when inserted in the boring, completely closes the opening.

"When readings are taken the observer removes the cover and withdraws the device at each depth from the boring. The maximum thermometer is read first. This can be done without drawing the device entirely from the opening. After reading the minimum thermometer, the marker is adjusted at the head of the column. The maximum is then detached from the device and thrust into a vessel of ice water before the instrument is whirled to force the mercury back into place. This procedure is necessary if the temperature of the air is greater than that of the soil, as it usually is in summer. The probability of error in the reading arises from permitting the maximum thermometer to come in contact with the air above ground when it is warmer than the soil and before the reading is taken. Error may also arise from the shifting of the marker in the minimum thermometer in withdrawing it from the boring. Repeated observations show that if the maximum thermometer is retained in the well while the reading is taken there is no movement of the column of mercury. Observations also show that when reasonable care is taken in withdrawing the device from the boring and it is not jarred or tipped at an angle greater than 10°, the marker does not move."

(*c*) Continuous soil temperature records.

Specially constructed soil thermographs are on the market. They are distance mercury-in-steel thermometers with the usual recording devices.

Apparently the use of such thermographs is subject to conditions which have been under investigation for some years, but about which little information of a definite nature seems to be available.

Electrical Thermometers

Since the electrical measurement of temperatures is becoming more and more popular in certain phases of biological research, a few words will be said about the instruments used in this work.

Electrical measurements of temperature can be made with great accuracy and over a wide range. In biology they are especially useful for measuring very small changes in temperature or for measuring temperatures in places where ordinary methods are impractical or impossible for various reasons.

Resistance Thermometers

There are two principal types of electrical thermometers, namely, resistance thermometers and thermo-couples. Although for biological work the latter are the most important a brief description of the former is given here for the sake of completeness.

The resistance of a conductor is defined as "the ratio of E. M. F. (electromotive force) applied at its ends to the current strength resulting". Resistance varies with the dimensions of the conducting body, its shape, its material, etc. Moreover it depends on the temperature of the body. Thus the resistance of pure metals and of most alloys is increased by a rise in temperature. Upon examining the resistance curves of a number of different metals, they will be found to converge towards a point which would be O, if determined experimentally and corresponds approximately to—273 C. or what is known as the absolute zero of nature. All the curves have a long radius of curvature, hence within comparatively small ranges, they may be regarded as straight lines, which of course would mean that the resistance is practically constant between such limits. The metal exhibiting the most perfect correlation between temperature and resistivity is Platinum. The fact that the electrical resistance of this metal is practically a simple function of its temperature was used in the construction of the resistance thermometer, an instrument exceeding both in accuracy and in range, the ordinary mercurial thermometer. The first of these thermometers for practical purposes was constructed by Sir William Siemens in 1871. Several forms and arrangements were known previously but were not practical. The Siemens thermometer, however, was itself unsatisfactory in constructional details and soon became forgotten. In 1886, Callendar constructed a new type of resistance thermometer and greatly perfected the instrument. The instrument consists of a tube of hard glass or porcelain fitted with a hard rubber cap in which four binding posts are set. One pair of binding posts is connected by means of two thick copper leads to a double

wire of pure platinum which is wound on a thin mica frame near the end of the tube. The second pair of binding posts is connected to two dummy leads, similar to the real leads and joined together at their lower ends. The false leads are introduced to compensate for the error resulting from the fact that the resistivity of the lead wires is increased with increased temperature as well as that of the platinum wire, which latter is the one to be measured. All four lead wires terminate at about the same place in the instrument and they run close together so as to be always at the same temperature. The resistance is measured by means of a Wheatstone bridge, between the binding posts leading to the platinum wire. Whilst this is measured, the dummy leads are introduced into the circuit of the adjacent arm of the bridge so that any resistance of the real lead wires is balanced by a similar resistance in the dummy leads.

The electrical measurements are convertible into degrees temperature by means of tables or by direct calculations based on the specific thermoelectric co-efficient of platinum. Such thermometers are said to be very accurate up to 1000°C. There are recording instruments of this type. (See above.)

Thermo-couples

In 1828, Secheck discovered the fact that when heat is applied at the junction of two dissimilar metals an electromotive force is generated. From that time many attempts were made to use this basic principle in the construction of thermo-electric pyrometers. Most of these ended in failure because the great susceptibility of the thermo-electric properties of metals to slight chemical and physical changes was not fully understood. In recent years, however, the thermo-electric measurement of temperatures has attained a degree of perfection unequalled by that of any other method.

The principle upon which the operation of the thermo-couple is based is that, when two dissimilar metals are joined, an electromotive force is set up at the point of contact and that this force is proportional to the temperature at that point. Now, when two such junctions are made and one is held at O°C. whilst the other is subjected to some higher temperature, the current from the warmer junction will pass the current from the colder junction and the measurable force in the system will be proportional to the difference between the temperatures of the junctions.

A thermo-electric pyrometer consists of five principal parts:

(1) The thermo-element or thermo-couple which is a junction of wires of two dissimilar metals.
(2) The insulating material of these wires and the protecting tubes.
(3) The potentiometer or measuring instrument.
(4) The device for controlling the temperature at the "cold junction".
(5) The wiring system and switches when several thermo-couples are used.

Each of these will be discussed briefly in the following:

A. The thermo element.—The ideal metals for the construction of thermo-couples are platinum and its alloys. The cost of such an element being very great, some of the base metals are commonly used for this purpose. The choice of such base metals must be governed by the temperatures to be measured. Below 300°C. copper-constantan junctions are used.

Iron-constantan combinations may be used up to 800°C, but this junction is subject to many changes which may produce considerable error.

Iron-nickel was once extensively used, but has been abandoned because of oxidation to which it is subject. (Nickel also undergoes molecular transformation between 230°C. and 390°C.)—It is satisfactory between 400° and 800°C.

Nickel-chromium, nickel-aluminium also known as Chromel-alumel couple, is used at very high temperatures up to 1100°C.

Base metal couples generate about four times the E.M.F. per degree of a platinum-rhodium couple. This is a distinct advantage, on the other hand, under prolonged exposure to high temperatures their E.M.F. gradually decreases and frequent standardization is necessary.

The rare-metal couples are mostly either Platinum-Platinum-Rhodium or Platinum-Platinum Iridium.

B. Insulation and protecting tubes.—The choice of materials for protecting sheaths of the wires and external protecting tubes is also determined by the use to which the instrument will be put. Among the materials in use are hard glass, fused silica, alundum, carborundum, graphite, nichrome, etc., etc. Fire clay and porcelain are used for electrical insulation.

C. Temperature indicators.—In industrial work, thermo-couples are usually equipped with moving coil indicators or millivolters. The scales are generally graduated in degrees temperature and thus may be read directly. Such instruments are highly sensitive and often have a full scale deflection for 10 millivolts. However, in the ordinary instrument used in the industries accuracy is only to be obtained to within 5°C. For higher accuracy potentiometers are used. With a low-resistance potentiometer and a sensitive moving coil galvanometer, it is possible to measure to 1 microvolt.

There are many types of potentiometers but the discussion of the different types involves many technicalities into which we cannot enter in a paper of a general character.

D. Cold junction device.—For accurate work it is necessary to maintain constant temperatures at the so-called cold junction. This is done by inserting the junction in a vacuum bottle containing water and ice. In such bottles, a handful of ice will maintain a constant 0° temperature for many hours. In some

cases this is not possible and corrections must be made to allow for the temperature of the cold junction.

E. Switches.—When several thermo-couples are read on the same meter, a common cold junction is used for all. A multi-point switch permits the reading of any one system at a time.

What has been said thus far relates to thermocouples and potentiometers in general. Instruments used in biological work are of special construction. There are several types and makes. Probably one of the most satisfactory indicators is the type developed by Dr. Northrup, it is known under the name "pyrovolter." It is a deflection instrument and hence indicates voltage without extracting any current from the source of the electromotive force that is being measured. In the ordinary type manipulation is very simple. This pyrovolter is used for commercial work, but from it an instrument known as the microvolter has been developed for the accurate measurement of temperatures within the range usually encountered in biological investigations. The principal advantage of all these instruments consists in the fact that they measure potential and not current and hence are not affected by changes in resistance in the instrument. The microvolter has a very low range (between 50 and 1000 microvolts ($\frac{1}{1000000}$ volt full scale). For measuring potential differences of a magnitude less than 1 millivolt, it is necessary to use an external galvanometer for zero setting, because the standard pyrovolter is not sufficiently sensitive. (Zero setting is the first step in making measurements by means of the pyrovolter and has for effect the balancing of the unknown E.M.F. with any drop across an adjusted fixed resistance.) The scales of the microvolter may be graduated to read directly in degrees temperature. When it is intended to use several thermo-couples a mercury cup selector switch is used for making rapid connections.

THE MEASUREMENT OF ATMOSPHERIC HUMIDITY AND PRECIPITATION

A.—Atmospheric Humidity:—

The water vapour present in the atmosphere is derived, through evaporation, from the oceans, the inland seas and rivers, and from the earth. The relative action of these sources of atmospheric water vapour, is no doubt of great importance and may be gauged to some extent by a comparison of the volume of water represented by each. G. F. McEwen, using the volume of water in the ocean as a unit, gives an idea of the distribution of water as follows:

Volume of water in the ocean	1.0
Volume of water in the soil	0.005
Volume of water in inland seas and lakes	0.00009

Measured by the same scale, the average volume of water in the atmosphere is only 0.000009. When water passes into the atmosphere in the form of vapour, it is distributed unevenly by the air currents and the quantity of vapour present varies both in space and in time. Temperature is the principal factor in determining the amount of water vapour which may he held by a given volume of air. The limit at any given temperature is reached when the vapour pressure of the liquid and that of the atmosphere are in equilibrium. The temperature at which this condition of saturation is realized is the "saturation point". Under this condition the air is said to be "saturated," that is to say, any further addition of water results in condensation or any drop in temperature will produce the same result. The temperature at which water vapour is condensed into fog, cloud or precipitation is known as the "dew-point." Any rise in temperature, on the other hand, will upset the equilibrium in favour of the vapour pressure of the liquid and permit the further absorption of vapour by the atmosphere. The total weight of water contained in a given volume of air is referred to as "*absolute humidity.*" The amount of water vapour usually contained in a volume of air expressed in percentage of the possible amount at a given temperature is the "relative humidity."

The influence of the presence of water vapour in the atmosphere upon biological phenomena in general is too well realized to require any special treatment and is a subject outside of the scope of the present paper. From a meteorological standpoint the following effects are worthy of notice: (1) Water vapour absorbs infra-red radiation more readily than does the air. Hence, humid air is heated more than dry air by solar radiation.

(2) The phenomena of vaporization and condensation are accompanied by the absorption or emission of considerable amounts of heat. The latent heat of vaporization of water is very high, thus the production or the condensation of one Kilogramme of vapour is able to effect a change of temperature of 1° centigrade in 2000 cubic metres of air.

(3) The rate of evaporation from land or water is greatly affected by the humidity of the atmosphere.

(4) The atmospheric water vapour not only produces fogs, clouds, rains, etc., but it plays an important part in the formation and maintenance of such dynamic phenomena as cyclones.

Measurement of Atmospheric Humidity

The proportion of water vapour present in the air may be determined in various ways:

(1) By weight.—By determining the weight of water vapour present in a cubic metre or a cubic foot of air, a measure of absolute humidity is obtained. This method is not practical.

(2) By vapour pressure.—Water vapour acts as any other gas and, as such, exerts a certain pressure. This pressure is proportional to the amount

of vapour present, hence it may be used as a measure of absolute humidity. The total pressure of the atmosphere minus the pressures of all normal constituent gases present gives the pressure of water vapour. Thus when the atmosphere is saturated, vapour pressure will be at its maximum. Tables for the determination of vapour pressure (or absolute humidity) are found in the first part of the Psychrometric tables of the U. S. Weather Bureau. To determine the vapour pressure, first find the dew-point. Opposite the latter in the table we find in the second column, the value for vapour pressure.

(3) By relative humidity.—What is implied by this term has been sufficiently explained.

The determination of relative humidity is made readily by means of such tables as the U. S. Weather Bureau Psychrometric Tables.

It is possible to determine absolute humidity from relative humidity if the maximum vapour pressure at a given temperature is known. The formula used is

$$\frac{h \times F}{100}$$

where h = the relative humidity

F = the vapour pressure at saturation.

Tables for the latter are available.

Instruments.—The instruments used for the measurement of humidity may be divided into two principal classes.

(1) Wet and dry bulb hygrometers based on the principle of the lowering of temperatures by evaporation.

(2) Hygroscopic hygrometers—principally hair-hygrometers—based on the principle that many organic substances undergo considerable alteration in their dimensions, upon being exposed to moisture.

a. Wet and dry bulb hygrometers.—The principal distinction in this class of hygrometers depends upon their use either in still air or in moving air. The ordinary wet and dry bulb instruments belong to the first category, whilst the Assmann aspirators and the sling psychrometers belong to the second.

These instruments are widely in use, yet, many misgivings exist as to the formulae to be used for the reduction of readings. It would be impossible to give an exact and scientific treatment of this important point in a paper of this kind, but the following excerpt from the "Dictionary of Applied Physics" will give a general idea of the points at issue.

"The formulae are in general of the type due to Regnault:

$$E'' = E' - AB\,(t - t')$$

Where E″ is the vapour pressure at the dew-point, E′ that at the temperature of the wet bulb, t and t′ the temperatures of the dry and wet bulbs, B the barometric pressure measured in the same units as those employed for E″ and E′, and A a quantity depending on the wind velocity in the neighborhood of the thermometers.

"Prentner has given the values in the following table, if the water on the wet bulb be not frozen:

Vapour Pressure at the Dew-point

State of wind in screen	Temperature in Centigrade degrees	Temperature in Fahrenheit degrees
Calm— 0 – 0.5 m. per second....	$E' = .0012B(t-t')\left(1+\frac{t'}{610}\right)$	$E' = .00067B(t-t')\left(1+\frac{t'-32}{1098}\right)$
Light wind— 1 – 1.5 m. per second....	$E' = .0008B(t-t')\left(1+\frac{t'}{610}\right)$	$E' = .00044B(t-t')\left(1+\frac{t'-32}{1098}\right)$
Strong wind— Above 2.5 m. per second.	$E' = .000565B(t-t')\left(1+\frac{t'}{610}\right)$	$E' = .000364B(t-t')\left(1+\frac{t'-32}{1098}\right)$

"Recent experiments in a wind channel at the Royal Aircraft Establishment at Farnborough have shown that for the ordinary range of temperature and humidity the constant A shows no appreciable variation up to speeds of 90 miles an hour (say 40 metres per second) from values given in the table for strong winds.

"If the wet bulb cover is frozen, the co-efficients become .001060, .000706 and .000579 respectively, while the 610 in the denominator becomes 689.

"The instructions of the Bureau Central Météorologique prescribe a formula

$$E'' = E' - .00079B(t-t')$$

while in India the formula

$$E'' = E' - .00079B(t-t')\ \left(1+\frac{t'}{610}\right)$$

is employed. These two practically agree with Prentner's light wind formula. The formulae for a strong wind are suitable for use with Assmann's ventilated and the sling hygrometers. *For the latter* the following formula,—in Fahrenheit degrees,—*is employed in America:*

$$E'' = E' - .000367B(t-t')\ \left(1+\frac{t'-32}{1571}\right)$$

which, in view of the smallness of the term $\frac{t'-32}{1571}$, is practically the same as Prentner's strong wind formula.

"The tables used by the Meteorological Office, are based on Glaisher's factors or multipliers, making use of the equation

$$d = t - A\,(t-t')$$

where d is the temperature of the dew-point, t and t′ the temperatures of the wet and dry bulb respectively, and A a factor determined from the comparison of many thousand simultaneous observations of wet and dry bulb thermometers and of the Daniell Hygrometer taken at the Royal Observatory, Greenwich, from 1841 to 1854, and from observations at high temperatures in India and at low temperatures in Toronto. The values of Glaisher's factor A depend on the dry bulb temperature, and a table is given in the Computer's Handbook, from which the following is extracted:

Values of Glaisher's factors used for dry bulb temperatures from 265 A to 314A

Temperature A	Glaisher's factor	Temperature A	Glaisher's factor	Temperature A	Glaisher's factor
265	8.55	278	2.26	293	1.79
266	8.27	279	2.21	294	1.77
267	7.63	280	2.17	295	1.75
268	7.28	281	2.13	296	1.74
269	6.61	282	2.10	297	1.72
270	5.80	283	2.06	298	1.70
271	4.92	284	2.02	299	1.69
272	4.06	285	1.99	300	1.68
273	3.32	286	1.95	301	1.67
274	2.81	287	1.92	302	1.66
275	2.54	288	1.89	303	1.65
276	2.39	289	1.87	304	1.64
277	2.31	290	1.85	305	1.63
		291	1.83	306	1.62
		292	1.81	307	1.61
				308	1.60
				309	1.59
				310	1.58
				311	1.57
				312	1.56
				313	1.55
				314	1.54

The above excerpt will give an idea of the different methods of reducing wet and dry bulb readings and at the same time it contains a warning against the indiscriminate use of humidity tables.

Since, in this country, the psychrometric tables of the U. S. Weather Bureau are the ones most commonly in use, it may be well to call attention to a statement by Dr. Marvin in the introduction to the U. S. tables:

"The formula and tables are strictly applicable only to wet and dry bulb temperatures as determined by means of the sling, or whirled psychrometer, or some equivalent form of apparatus in which the wet bulb especially is subjected to a strong current of air, the velocity of which is not less than 15 feet per second."

The sling psychrometer is a very simple yet a very excellent instrument for measuring atmospheric moisture. It is essential, however, that the thermometers used be of the finest quality and that they be well matched. If we begin by obtaining a good instrument many troubles will be eliminated, but even then, it seems highly advisable to have the instrument tested periodically at some laboratory equipped for this work.

The preparation and care of the wet bulb thermometer is a matter of paramount importance. Both the material of the wick and its cleanliness largely determine the degree of success with which the instrument can be used. If the material is too thick or if it is wrapped several times around the bulb, it will take considerable time to reach a steady temperature on the wet bulb. Thin muslin, closely woven and wrapped one and a half times around the bulb seems to be the most satisfactory material. The manner of fitting the wick to the bulb is described in detail in the preface to Marvin's "Psychrometric tables." If the instructions given in this book are closely adhered to, there should be but little chance for failure. Loosely woven muslin must not be used because it will not keep the entire surface of the bulb uniformly moist. All sizing and traces of grease or oil should be scrupulously removed from the muslin. This may be done by boiling the muslin before use, in a dilute solution of potash, taking great care to wash out thoroughly all the potash before fitting the wick to the bulb. A supply of prepared muslin may be kept in pure alcohol. In adjusting the wick to the bulb, every trace of grease should be removed from the hands. Finally, any material will sooner or later harden and when this happens, it should be discarded. Discoloured wicks should always be rejected. Distilled water should be used for moistening, to prevent the deposition of salts. Moisture may be applied either with a clean camel's hair brush or by dipping the bulb in a vial of clean water.

Recording instruments for the study of atmospheric water vapour are known as hygrographs. They are of two principal types. The dry and wet bulb hygrograph and the hair hygrograph. These instruments and the principles on which they are operated are too well known to require detailed description. For the study of relative humidity etc., the wet and dry bulb hygrograph is reliable only when the bulbs are properly exposed and subjected to a fairly strong air current. Many modern instruments are equipped with electric fans for this purpose. From what has been said before, it is quite evident that the proper reduction of the readings depends entirely upon the rate of air flow over the bulbs. If the flow is maintained at not less than 2.5 to 5 meters per

second, the ordinary psychrometric tables may be used in interpreting the readings.

The basic principle of hair hygrometers is the fact that human hair freed from its natural oil and all trace of grease of any kind, is highly sensitive to moisture. Human hair may be made chemically clean by a bath, first in water with a mild soap and, after drying, in ether. *After the ether bath it should not come in contact with bare hands.* A strand of several hairs is so mounted that its contractions and expansions actuate a system of levers which govern the movement of a pen on a chart mounted on a clock-driven drum. The instrument is so calibrated as to give direct tracings of the relative humidity. Such records are not always trustworthy, but the errors are easily checked and the necessary adjustment can be made. Hygrographs are more or less sluggish, to compare the readings of these instruments with those of the sling psychrometer, it is necessary to make several observations and to take the average of the readings for comparison.

Another method for checking hygrographs is to place them under a bell jar with moistened sides, after a time the instrument should indicate a R. H. of 95. The same effect should be obtained on any rainy day when the sling psychrometer depression is 0. Some observers, moisten the hairs of the hygrometer by applying clean distilled water with a camel's hair brush when, after a while, the pen should be at 95%.—The latter method is not generally recommended. Readings above 90% on hair hygrometers are not entirely reliable. A certain amount of good judgement is always required in making these tests, the main thing to be remembered is that a single reading of the sling psychrometer does not furnish the necessary information for making adjustments on the hair-hygrograph.

Touching the hairs with bare hands may render the instrument completely unreliable. If this happens, new hairs should be installed or the old hairs should be made chemically clean by the method described above.

B. Precipitation

Rain:—It is only on very rare occasions that atmospheric water vapour is directly condensed into rain. Usually it must pass through an intermediate stage of fog or cloud. Rain is produced by the coalescence of the water droplets in clouds or fogs. In the great majority of cases, rain is caused by adiabatic cooling. The cooling producing clouds and fogs is the initial stage. Further cooling results ultimately in the formation of the larger drops, which having greater weight, fall to the ground. When a strong warm current of air with a high humidity content is driven upwards, for instance, along a steep mountain slope, the velocity of the air thus deflected upward is sufficient to produce a rapid fall in temperature and a heavy precipitation will result. Similarly, a rapid updraft may be produced at a surface of discontinuity separating warm and cold air at

the same level and the same result will naturally follow. Thus the surface of discontinuity between polar and equatorial air, which constitutes the very variable polar front becomes one of the important factors in world precipitation.

Rain intensity as calculated by the month or the year is a very variable quantity and conclusions for any region must be based on statistical information based on observations for a large number of years.

Rainfall is measured by the thickness of the layer of water produced on a perfectly flat, impermeable surface. Rain gauges are used for this purpose. The ordinary rain gauge and its operation are well known. There are also registering gauges, known as tipping-bucket gauges. In these, usually, the intensity in hundreths of an inch is recorded on a clock-driven drum. The important point in the installation of a rain gauge is its height above the ground. The height usually recommended for the mouth of the gauge is 1 meter above the ground. When the gauge is placed on the ground it receives too much water, if it is placed too high it receives too little.

THE MEASUREMENT OF LIGHT

The measurement of light, whether direct sunlight or diffused light, is a complicated procedure and it seems quite sufficient for the purpose of this paper to confine ourselves to a few remarks on some simple methods of measurement of direct sunlight.

With ordinary, readily available instruments we are in a position to ascertain not only the duration of sunshine, but to a certain extent its intensity.

For the study of the duration of sunshine several types of instruments have been devised. Among these the Campbell-Stokes sunshine recorder is probably the most commonly in use. It is the familiar glass ball type and its construction and operation are so simple as to require no further comments. Care should be taken that the instrument is properly adjusted.

1. The centres of the glass sphere and of the bowl must be coincident.

2. The plane containing the central line of the recording surface must pass through the centre of the glass and coincide with the equator.

3. The vertical plane through the centre of the sphere dividing the bowl into equal parts, must coincide with the meridian.

4. The principal focal length of the glass sphere for heat rays must be equal to radius of the bowl at the surface of the recording card.

5. When the card is in position, the hour lines must lie in the plane of meridians of the celestial sphere corresponding with hour angles (15°) measured from the geographical meridian.

The Marvin sunshine recorder is electrically operated, more easily installed and gives probably more exact records than the Campbell-Stokes recorder. It is essentially a differential thermometer, a straight glass tube with cylindrical

bulbs at each end, one of which is coated with lampblack. It is mounted in a glass tube in vacuo. A pair of electrical contacts are mounted at the middle of the thermometer stem. When the bulb is heated by radiation the mercury closes the circuit and thereby actuates the recording mechanism.

The intensity of sunshine can readily but roughly be measured in two convenient ways.

a. The Black bulb thermometer in vacuo. This consists of a sensitive maximum thermometer with backened bulb enclosed in a glass vacuum tube one end of which is blown into the shape of a sphere. The black bulb of the thermometer is placed in the centre of this sphere. At best, this instrument is only an "indicator" and is subject to considerable error from many causes.

b. The Black bulb atmometer. The comparison between readings of black bulb atmometers and ordinary white bulb atmometers, exposed under, as nearly as possible, the same conditions, gives an indication of the relative intensity of solar radiation. It is claimed by Livingston, that this method of measuring radiation is one of the most exact available for the working biologist.

THE MEASUREMENT OF WIND DIRECTION AND VELOCITY

The wind is due to a displacement of masses of air. Usually, the trajectory of a particle of air thus moved is very much complicated by the action of obstacles or of other currents having a different direction. This is the cause of wind-gusts. Obstacles cause an accumulation of air, when this air is sufficiently compressed it reacts either by opposing the smaller currents or by adding its own velocity to that of the currents. On the other hand, the meeting of currents with different directions induces the formation of waves.

Winds vary considerably in their general properties. These depend on the origin of these winds, their velocity and the nature of the locality.

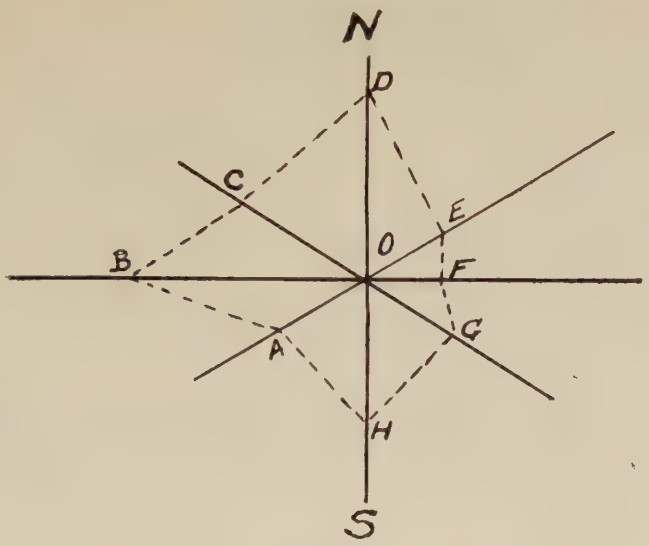
Wind direction

The direction of the wind is designated by the point of the compass from which it blows. Usually to determine the direction of the wind, wind vanes are used. A wind vane to work satisfactorily, must be very motile, well balanced and light. It should be placed at some high point away from the influence of buildings, trees or other obstacles.

Where no wind vane is available a flag or a "wind-bag" can be used to advantage.

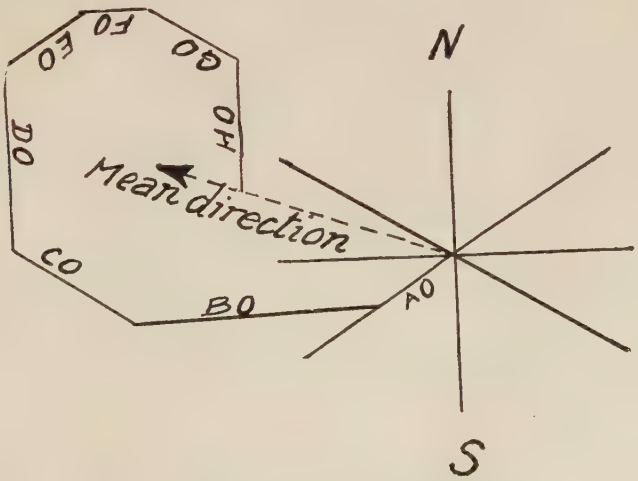
Since the direction of winds is extremely variable and since the properties of the winds depend largely upon their direction, it may be useful, at times, to know the mean direction for a certain period. This is found by means of a wind diagram, which is based on hourly observations and may cover any desired period. On the radii of a windrose the number of hours during which the wind

blew in the direction indicated by the radius is marked off. This will give a diagram as shown in fig. 2.



(Fig. 2)

The next step consists in treating the quantities marked off as a number of forces acting in various directions on one point, with a view to the determination of the resultant, which in this case will give us the mean direction. Applying this to the above diagram we obtain:



(Fig. 3)

The instruments used in the determination of wind velocities may be divided into three classes:

1. Cup and Fan anemometers.
2. Pressure-plate anemometers
3. Pressure-tube anemometers

Instruments of the first type simply measure the amount of air passing the cups or vanes in a given time. Instruments of the other two types depend upon the pressure effects produced by air currents, acting upon them. The distinction is evidently important when the latter type instrument is used at varying altitudes. The relation between wind pressure, density and velocity is

$$p = K\rho v^2$$

p = wind pressure; K = a constant; ρ = density of air; v = velocity

Hence $v = \sqrt{\frac{p}{K\rho}}$

or in other words the velocity varies as the square root of the quotient of the pressure by the density.

The Robinson cup anemometer

This apparatus consists of a kind of mill which rotates on a vertical axis. Four hemispherical cups are borne on two arms which cross each other at the centre. The pressure of the wind is greater on a concave surface than on a convex surface of equal diameter, hence the system rotates in the direction of greatest pressure. The relation of the speed of rotation of the cups to the true wind velocity depends upon several points of construction, such as size of the cups, length of the arms, etc. Moreover, inequalities in wind velocity will always tend to exaggerate the speed recorded, because the inertia of the cup system is affected more by the higher than by the lower wind velocities. In a good instrument the "cup-factor" is taken into account so far as it is influenced by the constructional details, but it is evident that to obtain an absolutely correct reading a velocity ratio should be established. This, however, is impossible from a practical standpoint and, therefore, the record of the Robinson anemometer must be considered only as an approximation.

The Robinson anemometer may be used to ascertain either the total or average wind velocities for a given period or, by means of an electrical device, the velocity at any one point in time. The usual mounting only furnishes the first mentioned record, but, ordinarily, the instruments are made in such a way as to make the second easily possible if it be required.

The Fan anemometer

This instrument is a diminutive wind-mill. In principle it is the same as the Robinson anemometer, but was constructed to obviate some of the objectionable

features of the latter. It is claimed that it gives a better reading than the cup windmeter. It is evident, however, that such effects as are due to varying velocities cannot be entirely eliminated. Some types of fan anemometers are equipped with stopwatches, the registering mechanism and the stop watch being actuated by the same lever. This device provides for greater accuracy.

The pressure-plate anemometer

The swinging-plate or pressure plate anemometer is simply a metal plate suspended on knife edges from a vertical frame. The wind blowing against this plate causes it to swing. The angle at which the plate is held at any moment may be read on an arc of a circle mounted directly below the lower edge of the plate and so calibrated as to indicate wind speeds corresponding to the angles described. The range of such a plate is small, but it may be increased by loading it with "bosses" attachable to its centre and thus increasing its weight. Supplementary scales are marked beneath the first scale to correspond to the effect of the added bosses. This instrument is readily portable and has, of late, been developed to give readings of considerable accuracy.

The pressure-tube anemometer

This apparatus is also known as the "Dines" anemometer. The principle upon which it works may be expressed as follows:

"When an open tube is placed in a current of air, there is produced inside the tube a pressure which differs from that outside (known as "static" pressure, the current being stilled) by an amount which is proportional to the square of the velocity of the current and to the density of the air:

$$p = p_s - K\rho v^2$$

where p = pressure inside the tube
p_s = " ouside the tube
k = a constant depending upon the shape of the tube and its presentation to the direction of the wind.

It has been found experimentally that there is a certain shape of opening which gives O for the value of k.
Hence $p = p_s$ and it becomes possible to measure the static pressure directly." (Geddes).

The description of this instrument may be found in any text book on Meteorology and is omitted here because it cannot be presented without a number of diagrams.

A word should be said here about the Beaufort Scale. In 1805, Admiral Beaufort drew up a scheme showing a definite relation between the speed of the wind and its effect upon different objects which could be readily observed.

The following table gives the Beaufort Scale in miles per hour at 33 ft. above the ground surface.

Scale No.	Character of wind	M.P.H.	Effects
0	Calm	1	Smoke, rise vertically.
1	Light air	2	Smoke drifts, but wind vanes not affected.
2	Light breeze	5	Leaves rustle, wind vanes turn.
3	Gentle breeze	10	Leaves and small twigs in constant motion, light flag extended.
4	Moderate breeze	15	Small branches moved, dust raised.
5	Fresh breeze	21	Small trees in leaf begin to sway, crests on wavelets.
6	Strong breeze	27	Large branches in motion, telegraph wires whistle.
7	High wind	35	Whole trees in motion, walking difficult.
8	Gale	42	Twigs broken, progress very difficult.
9	Strong gale	50	Damage to buildings (slight).
10	Whole gale	59	Trees uprooted, buildings severely damaged.
11	Storm	68	Widespread damage.
12	Hurricane	75	" "

In connection with wind velocity, two principal variations should be noted:

1. Variation with altitude.
2. Diurnal variation.

The swiftest winds are encountered, in temperate regions, at a height of 5 to 7 miles, just beneath the stratosphere. The slowing up of the wind near the ground is largely due to friction and the action of obstacles. At a height of about 7 miles (11 km.) the velocity decreases suddenly and approaches that near the surface. From 3000 ft. to 7 miles the increase is regular and follows a law: "With increasing height the velocity of the wind increases at the same rate as the density of the air decreases, hence VD = k (constant)". This is confined to certain limits (as indicated) within the troposphere.

The diurnal variation in velocity is equally well defined. Near the surface, the velocity is greater during the daytime than at night, whilst in the higher levels the opposite is found. This effect is due to solar radiation. Air heated near the surface is drawn upward, its own speed is increased thereby, but the speed of the upper layers is lessened. At night this mixing ceases and the inherent velocity of the different regions becomes more marked.

THE MEASUREMENT OF ATMOSPHERIC PRESSURE

The most conspicuous effect of variations in temperature is the variation in the atmospheric pressure and the consequent displacement of air masses.

Atmospheric pressure is due to the weight of the air. The air being a gas or rather a mixture of gases, this pressure is exerted equally in all directions.

The value of this pressure on any one point may be expressed in terms of the weight of a column of air 1 cm^2 in horizontal section and reaching in height to the outer limits of the atmosphere. Hence by the term "atmospheric pressure" we may understand either the elastic force of the air or the weight which it supports. Two principal causes of variation in pressure are the height of the column and the condition of the atmosphere, especially its temperature.

Differences in temperature cause movements of the air, convection currents, which may produce innumerable variations in pressure at different points on the earth's surface, and since these movements of the air are continual, produce also continual variations at anyone point.

If the temperature were constant, the pressure at any altitude would be the same everywhere.

Hence, we may expect that since oscillations in temperature are both irregular and regular, the same will be true of oscillations in pressure.

Irregular Variations

The amplitude of the irregular variations in pressure varies from place to place and from season to season.

The method of procedure in studying these variations consists in finding the mean maxima and mean minima for every month over a series of years. The range between these two represents the mean of the irregular variations for any predetermined locality and month.

By this process it has been found that in temperate zones, irregular variations are more important in winter than in summer, being at maximum in January and at minimum in July.

Furthermore, irregular variations increase directly as the distance from the equator.

Irregular variations may occur so violently and rapidly as to make the reading of the barometer difficult. Thus when a violent wind is suddenly stopped by an obstacle, pressure will be greatly increased. Oscillations due to this cause may amount to as much as 6 mm.

Regular Variations

a. Diurnal.—The regular variations of pressure are most easily observed in the tropics, where the irregular variations are small. In such regions a double oscillation of the barometer has been observed. Thus, from 4 a.m. to 10 a.m., the barometer rises. From 10 a.m. to 4 p.m., it falls. Then again from 4 p.m. to 10 p.m. in the evening it rises and falls from 10 p.m. to 4 a.m. There are, therefore, two daily maxima and minima.

In temperate and cold zones, these regular variations are obscured by the irregular ones. By studying the *monthly mean* of the hourly variations, the regular variations may be deduced. By this method it has been found that,

in temperate regions, there is daily a double oscillation of the barometer. However, the hours of maxima and minima vary with the season. The morning maximum and minimum come *earlier* in summer than in winter, whilst the evening maximum and minimum occur *later* in the summer than in winter.

b. Annual.—The mean monthly pressure shows an annual rhythm. The amplitude of this annual barometric oscillation is but feebly marked at the equator, where the season is fairly uniform. At higher latitudes, however, it becomes more or less noticeable. Nevertheless, the factors influencing it most distinctly are *not latitude*, but rather *altitude* and the *repartition of land and water areas.*

1. Altitude: In the summer the lower layers of the atmosphere expand and, therefore, a part of them passes to higher levels. Hence the weight or pressure is increased at such points. It has been found that at sufficient altitude, as on mountains, the difference is sufficient to produce a higher mean monthly pressure in summer than in winter.

2. Distribution of water and land: This is more complicated but in a general way, it may be said that in summer an overflow of warm air from the continents on to the oceans increases the pressure, the reverse taking place in winter. This displacement is complicated by movements from north to south and vice-versa, according to the differences in temperature at different latitudes. The final effect of all this, however, is the production of three types of variations in barometric pressure:

1. The continental type—maximum in January, minimum in July;

2. The oceanic type—maximum in winter and again in July; minimum in spring and again in autumn.

3. The Arctic type—maxima in April and again in November; minima in January and July.

In studying the distribution of pressure at the earth's surface, isobaric surfaces and curves are determined and the gradient between adjoining curves is determined.

a. Isobaric surfaces.—As was stated above, if the temperature of the atmosphere were constant, the pressure at any one altitude above the surface of the earth would be the same everywhere. Hence the various values would be represented by spheres concentric with the earth. As a matter of fact, pressure varies everywhere and the area representing any one value would be, not a perfect sphere, but rather a spheroid with numerous irregular elevations and depressions which might be roughly compared to huge mountain ranges and valleys. A spheroid of this kind is an isobaric surface.

b. Isobaric curves—or isobars.—The intersection of isobaric surfaces with the plane of sea level would occur along a line of irregularly situated points,

which, represented on a map, are termed "isobars" or isobaric curves. It is evident that with an atmosphere, perfectly at rest, no such curves would be traceable. Hence, the less disturbed the atmosphere, the wider the isobars become separated from each other, and vice-versa.

c. The gradient.—The "gradient" in this case is simply a numerical expression of the relative distance of two isobars measured on a perpendicular drawn between them. The gradient is its daily quantity and is found by dividing the difference in pressure by the length of the perpendicular (the distance between the two points of intersection).

It is usually measured in millimeters or millibars as divided by terrestrial degrees. (1° = 115 km)

It is evident that the gradient represents the inclination of isobaric surfaces on a horizontal plane (sea level).

An examination of a map showing the isobaric curves will reveal at once a greater regularity and parallelism on the southern hemisphere than on the northern. As in the case of the isotherms the explanation must be found in the predominance of oceans over land areas.

Atmospheric pressure is measured by barometers. There are three principal classes of barometers, the mercurial, the aneroid and the hypsometric barometers—(Water and glycerine barometers are not considered here).

a. Mercurial barometers.—The mercurial barometer consists essentially of a reservoir filled with mercury, into which a glass tube some 36 inches (80 cm) long and closed at one end having been filled with mercury, is plunged with the open end downward. When this is done, the mercury in the tube descends to a certain level, above it, there is a vacuum. The distance between the level of the mercury in the reservoir and that in the tube, is a measure of atmospheric pressure. Three qualifications are necessary for the satisfactory operation of a barometer. 1. The tube must have a large diameter, to avoid errors due to capillarity (at least 1 cm). 2. The mercury must be pure and the space above the mercury column must be a complete vacuum. 3. It must be possible to determine with great exactitude the variations in the height of the column. Among the various types of mercurial barometers may be mentioned the Normal barometer, the Fortin and the Tonnelot (Kew pattern).

The normal barometer is the most exact, it has a tube 3 cm. in diameter. The height of the mercury is determined with great exactness by means of a cathetometer. It is an expensive instrument which cannot be easily transported.

The Fortin barometer.—The distinguishing feature of the Fortin type, consists in the mechanism provided for adjusting the level of the mercury in the reservoir. There is a movable bottom in the latter, which can be adjusted by

means of a precision screw. In the cover of the reservoir a small ivory peg indicates the height to which the level of the mercury must be brought to obtain a correct reading at the top of the tube. The reading is accomplished by means of a vernier. A thermometer is usually mounted in contact with the mercury column. In transporting the instrument the bottom of the reservoir is screwed upward until the tube is completely filled, this eliminates any movement of the mercury and danger of breakage.

The Tonnelot barometer (Kew pattern barometer).)—This barometer is essentially the same as the Fortin, except that the bottom of the reservoir is not movable or, if movable, is only provided as a safe means of transportation. When the instrument is in operation the bottom is screwed down as far as it will go. On the other hand, the error due to differences in level is compensated by a special system of graduating the scale. In the Fortin type all graduations are equal, in the Tonnelot, they are compensated for error in the level of the reservoir. At the reading 1000 m., when the instrument is at its fiducial temperature, the divisions on the scale are less than the true length and below this point they are greater. The difference in the markings is proportional to the difference in the diameters of the reservoir and the mercury column. Supposing that these diameters are in the ratio of 10:1, their sections must be in the ratio of the square that is to say 100:1. Hence if the level of the column in the tube rises 0.99 mm. the level in the reservoir will fall 0.0099mm. The true difference in the distance between the levels, being the sum. On the basis of this ratio the graduations of the instruments are compensated.

Corrections.—The readings of a mercurial barometer must be corrected for temperature, for altitude and for latitude. Furthermore, there is usually a correction for error in the instrument (capillarity) the latter being furnished either by the maker or by the Bureau of Standards.

1. Corrections for temperature.—Two errors arise from a change in temperature. The one is due to a change in density of the mercury, the other to expansion or contraction of the scale. The following formula gives the correction required for a reading of the instrument at its "fiducial" temperature.

$$H \times \frac{1 + lt}{1 + mt}$$

H = height of the reading

l = linear coefficient of expansion of the scale.

m = coefficient of cubic expansion of mercury ($\frac{1}{5550}$)

t = temperature of the instrument.

Tables are available for this work, thus eliminating the need for calculations.

2. Corrections for altitude and latitude.—The specific weight of mercury decreases slightly with increase in altitude and also as one approaches the equator. The difference is slight and can usually be neglected except when two places are widely separated in latitude or altitude. Tables for making the corrections are available.

b. Aneroid barometers.—Essentially an aneroid barometer is a cylindrical metal box, with corrugated bases. A vacuum is created on the inside. The corrugations permit considerable displacement without appreciable resistance in the box itself. The metal usually employed in constructing these instruments is German silver. A strong spring mounted inside of the box furnishes the required resistance to atmospheric pressure, which would be sufficient to crush the box. As the pressure changes, the spring yields in different ways to it and these movements are communicated by a system of levers to a hand which moves on a graduated scale. The instruments can be very sensitive, but are subject to three principal sources of error:

a. Error due to weakening of the spring. The box flattens—the readings are too high.

b. Error due to temperature. The elasticity of springs depends to a certain extent on temperature. This error is largely overcome in "compensated" types of aneroid barometers by not completely exhausting the vacuum chamber.

c. Error due to friction in the levers. This may be overcome by gently tapping the instrument with the fingers, before making a reading.

As a general rule, aneroid barometers need to be frequently checked with standard mercurial barometers.

Recording barometers are a development of the simple aneroid barometer. The sensitive element consists of a series of vacuum boxes, which being placed one on top of the other produce a cumulative effect and allow for considerable sensitiveness of the apparatus. The recording mechanism is similar to that in ordinary recording thermographs. These instruments should be frequently checked for accuracy.

The hypsometric barometer is rarely used. Its operation is based on the principle that the temperature of the boiling point of water varies with atmospheric pressure.

Units of measurement of atmospheric pressure.—Suppose that the tube of a barometer has a section of 1 sq. inch. Roughly the height of the mercury column will then be 30 inches, and its content will be 30 cubic inches. One cubic inch of mercury weighs 0.49 lbs. Hence the total weight of the column will be 14.7 lbs. or about 15 lbs. to the square inch. At this rate the pressure on an area 1 ft. square will be 144 x 15 = 2117 lbs. or about one ton. The pressure may therefore be expressed either in terms of the length of a mercury column or in lbs. per surface. The first is the most convenient and the usual method. Thus, the

standard atmospheric pressure at O°C. and at sea level may be expressed as 760 mm. or 29.9217 inches. In comparing different pressures, a pressure of 15 lbs. per sq. inch = 1 atmosphere. In the metric system the pressure at O°C. and at sea level is 1.0322896 Kg. per cm^2 or 1.01327 x 10^6 dynes. Numbers such as the above are very cumbersome, hence new terms were adopted. One million dynes per square centimetre is called a "bar". 1/1000 of a bar = a "millibar." This 1/1000 of a bar, or 1000 dynes is now generally used in expressing readings of the barometer.

In this system one atmosphere is 1 megadyne (or 1000,000 dynes per cm^2). This expressed in mm = 750.1, in inches 29.531. The terms used in America are different from those used in Europe. The following table shows the principal points to be remembered.

Europe		America		Absolute units
1 bar	=	1 megabar	=	1 megadyne
			=	750.1 mm.
			=	29.531 inches
1 millibar (mb.)	=	1 Kilobar (Kb)	=	1000 dynes per cm^2
1 microbar	=	1 bar	=	1 dyne per cm^2

750.1 mm	=	1000 mb.	
1 mm.	=	$\frac{4}{3}$ mb.	
and			
1 mb.	=	$\frac{3}{4}$ mm.	(Geddes)

THE MEASUREMENT OF EVAPORATION

Evaporation—is the slow production of vapour at the surface of a liquid. It differs from boiling which is the rapid production of vapour in the mass of the liquid itself. Boiling of any substance takes place at a definite temperature whilst evaporation takes place at many different temperatures the range of which differs for different liquids.

The atmosphere is an obstacle to vaporization. Vapours exert pressure similar to the pressure exerted by gases. (For the technical distinction between gases and vapours see a text book of Physics). For the same temperature different vapours will exert different (specific) pressures. There is a limit to vapour pressure, when this is reached the vapour becomes *saturated*, this limit varies with temperature. When a vapour is saturated, both its density and its pressure remain constant, it is at its maximum. The *maximum pressure* is called the "*saturation pressure*" of a vapour corresponding to any *particular temperature*. At *saturation*, then, vapours differ from gases, since for a given tempe-

rature their pressure and density are constant independently of their volume. *Unsaturated* vapours on the other hand follow Boyles' law: "The volume of a gas at constant temperature varies inversely as the pressure", or "the product of the pressure by the volume is a constant", or again "For the same temperature the density of a gas is proportional to its pressure."

Finally, there are two laws governing all mixtures of gases and vapours: (1) The pressure and consequently, the quantity, of vapour which saturates a given space are the same for the same temperature, whether there is or is not any other gaseous substance in the space. (2) The pressure of the mixture of a gas and a vapour is equal to the sum of the pressures which each would exert if it occupied the same space alone. — These are known also as Dalton's laws.

The general principles enunciated above are at the basis of all phenomena connected with evaporation. For detailed information on these the reader is referred to any elementary text book of Physics.

There are four principal causes influencing the rapidity of evaporation from the surface of a liquid.

1. Evaporation is accelerated by increase in temperature, because, as we have seen above, vapour pressure is directly proportional to temperature.

2. Evaporation is directly proportional to the vapour pressure of the evaporating liquid and the pressure of the same vapour already present in the atmosphere. Hence, with an absolutely dry atmosphere the rapidity of evaporation will be at its maximum. With a saturated atmosphere it will be 0. Between these two extremes the rate of evaporation will be proportional to the respective pressures of the evaporating liquid and of the absorbing atmosphere.

3. It is also evident from the above that with an atmosphere at rest, the maximum rate of evaporation (supposing that the atmosphere be absolutely dry at the beginning) will be momentary and that it will decrease continuously as the quantity of vapour (or the pressure) increases. Hence, unless the atmosphere is renewed the vapour will become saturated and evaporation will cease. The effect of the renewal of atmospheres was studied by Dalton who found that the ratios of evaporation in a feeble, medium and strong draft were respectively as 270:347:424.

4. The rate of evaporation is proportional to the surface exposed. This is self-evident.

Besides the above factors, the pressure of the atmosphere produces a minor effect, the rate of evaporation being inversely proportional to pressure.

Ordinarily the measurement of the evaporating power of the air is accomplished by means of atmometers or evaporimeters. These are of two principal types the open surface and the porous cup atmometers.

The open surface evaporimeter may be a tank or a pan of known dimensions. The ordinary tank should be about six feet square and two feet deep, so that the mass of water may not become heated above the temperature of the surrounding air. The tank is filled to a known level and differences due to

evaporation are read by means of a ruled stick or in more exact work by means of a vernier.

Pans are mostly used for laboratory work and are not suitable for work in the open, because the water in them becomes easily heated above the air temperature, thus giving too high readings.

An improved evaporimeter of the pan type is described in Ecology XI, 2, 1930, by Stark and Whitfield. But since instruments of the above type are not used by the average biologist no special discussion is necessary. Might it suffice to state, that the reading of all ordinary evaporimeters of the open surface type are affected by the lowering of the water level and that this defect has been overcome by Stark and Whitfield whose improved evaporimeter has a constant reservoir level and is moreover not affected by rainfall.

In ecological investigations the Livingston porous cup atmometer is now very generally in use. The cup is spherical in shape and many workers have adopted mountings of their own invention.

It should be remembered that porous cup atmometers rapidly lose their standardization either through gradual changes taking place in the walls of the cup or through the deposition of foreign matter on its outer surface. Therefore, it becomes necessary to change the cups about every month and to restandardize them. Restandardization is accomplished by comparison with a cup with a known co-efficient. The proper way of doing this is to place the standard cup and the one to be restandardized on a slowly rotating table so as to insure an equal and even flow of air over the evaporating surfaces.

In connection with the latter point the following data excerpted from a table constructed by Shelford may be of interest.

Air velocity per second (approx.)	Evaporation per hour (approx.)	Temperature	Ratio	
			increase in flow	increase in evaporation
Meters				
0.012	0.25	22.4	1	1.0
0.026	0.40	22.2	2	1.6
0.052	0.75	22.2	4	3.0
0.104	1.50	22.2	8	6.0
0.208	2.00	22.2	16	8.0
0.416	2.60	22.2	32	10.4

The above figures, which Shelford states are only approximate, seem to indicate an arithmetical progression for the rate of evaporation corresponding to a geometrical increase in air flow. The methods of standardization are described by Shelford in his textbook "Laboratory and field Ecology."

The mounting used by Livingston in his first experiments was later modified in various ways especially with a view to making the instruments more

portable. These mountings are of two principal types, the absorbing and the non-absorbing mounting. When rain falls on the porous cup the minute menisci in the pores of the bulb are destroyed and water is drawn into the apparatus with a force proportional to the height from the level of the reservoir to the top of the porous cup. An ordinary mounting does not provide for the exclusion of water thus absorbed from the outside and is known as an absorbing mounting.

It consists simply of a straight glass tube which connects the reservoir with the porous cup. The tube passes through the stopper of the reservoir and the stopper which closes the stem of the cup, the upper end of the tube being level with the surface of the small end of the last named stopper. The cup is filled with water, the stoppers are arranged at the proper distance on the tube, the tube is next filled with water and is then joined to the cup. After this the cup and supply tube are connected with the reservoir. In the stopper which closes the mouth of the reservoir a fine U tube of glass or copper is fitted to allow the access of air into the reservoir. When filling the reservoir the mounting is either entirely removed, or to prevent this, a third opening may be bored into the reservoir stopper and fitted with a piece of glass rod. In the latter case, after the water has been introduced through the hole in the stopper, the opening itself is closed by means of the glass rod.

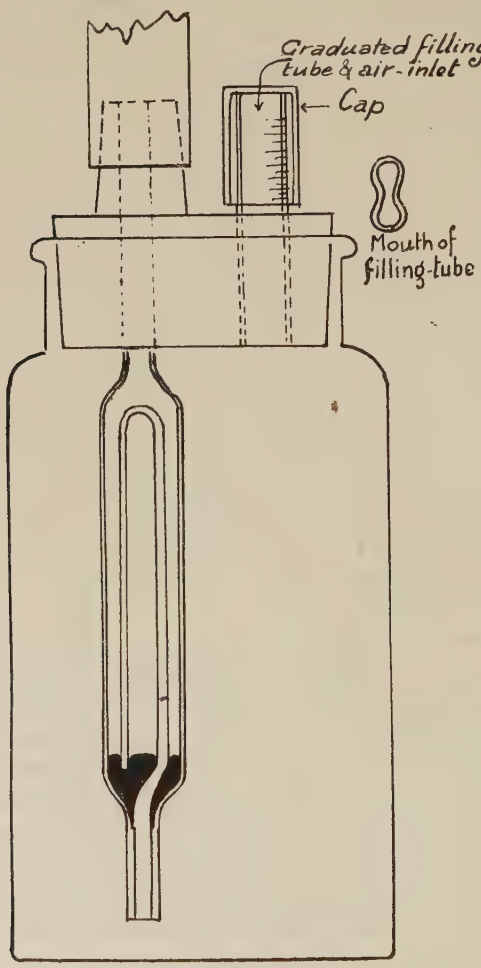
There are many types of non-absorbing mountings. The simplest of these is the Livingston-Thone valve, described by Thone in Ecology V, 4. A tight plug of glass wool is introduced at the bottom of the supply tube. Above this plug a drop of mercury is placed and at a short distance further up in the tube a second glass-wool plug serves to prevent the spilling of the mercury. This is the cheapest and the most easily constructed valve as yet described. It has some serious disadvantages, the principal one of these being the danger to health involved in handling glass wool. In this valve, the mercury acts as a plug preventing the passage of water downward into the reservoir. All the other valves are based on the principle of hydrostatic balance. Of these there are many, some more complicated than others. In the article by Thone, mentioned above, the principal different types are described in detail. Since the publication of Thone's paper a modification of the Shive valve was proposed by Wilson in "Science", Vol. LXXI, 23.

In a short paper in the 1930 Annals of the Quebec Society for the Protection of Plants, I have described somewhat in detail some of the valves used as well as a new type, which may be considered as a modification of the Johnston (1918) valve. The general objection to most of these mountings is the difficulty of construction. All valves, constructed on the hydrostatic principle, are subject to reversal error, which is equal to the volume of mercury required to establish the balance. This error varies in different types of construction and it is proportional to the diameter of the bore of the tube and to the height of the column of water. For further details, the reader is referred to the two articles mentioned above.

It might be useful to add a word about methods of taking atmometer

readings and the operation of filling.—After an atmometer has been exposed for some time the amount of water evaporated may be ascertained directly if a graduated burette is used as a reservoir, as in the original Livingston mounting. Such a mounting, however, is not convenient and the usual method consists in restoring the water in the reservoir to the level at which it stood when the atmometer was first exposed. A simple method of accomplishing this is to use a narrow-necked bottle as reservoir. At some convenient place on the neck of the bottle a mark is placed to indicate the level to which the bottle must be filled. The amount of water which it is necessary to add to restore the original level, is evidently the amount evaporated during the time of exposure. By using a narrow necked bottle a fairly open reading is obtained.

A simpler and possibly more exact method is shown in figure 4.



(Fig. 4)

In this mounting the air inlet and the filling hole are combined in one tube. This tube should be of fairly large diameter (about 8 or 10 mm). The mouth is constricted in the middle to form approximately a figure 8. The part of the tube projecting above the stopper may be either marked with a single line or graduated. When filling, the point of the burette is introduced into one side of the mouth of the tube, the air is allowed to escape through the other. The bottle is filled entirely and the water is allowed to rise into the filling tube until it reaches the desired level. The mouth of the tube is then covered with an inverted shell vial. If the mouth is properly made, air will enter through the filling tube. This method furnishes a very open reading and, if, accidentally, a mistake is made in the filling, any excess water can be easily removed or the difference noted in the next reading.

Quick reading atmometers and recording atmometers may be constructed. Probably the best type is the one described by Chalkley and Livingston in Ecology, 1929, X, 1. An atmometer for use in cages is proposed by Shelford in his text book on "Laboratory and Field Ecology", pp. 300-302.

The fixed dry and wet bulb thermometer may also be used as an instrument for measuring the rate of evaporation. The temperature of the wet bulb is governed by the rate of evaporation from the film of water surrounding it, hence the depression of the wet bulb is proportional to evaporation and may be used as a relative measure. This is probably one of the best uses that can be made of a stationary apparatus of this kind.

COMPLETENESS

Completeness of a meteorological record intended to meet the requirements of the biologist depends upon its continuity and upon the number and kind of observations taken. Continuity is an indispensable requisite, a single interruption of considerable proportions, may be sufficient to vitiate the entire record of a season. Interruptions may be due to apathy and negligence or to accidents. A few simple precautions in protecting the instruments will prevent most of the accidents, but, as the saying goes, accidents will happen even in the best regulated families. However, if a reasonably careful watch is kept over the instruments, such accidents will not often be the cause of interruptions of significant duration. The use of good recording apparatus will simplify considerably the problem of the continuous record, but it would be a serious mistake to believe that it completely solves the question. Even the best recording instruments need to be watched and checked at least daily, and often more frequently. Another and more important advantage of the recording instrument in insuring completeness of the record consists in the fact that it furnishes data, hour by hour of the fluctuations that take place during both night and day. The desirability and the practical value of such a record in some cases is well illustrated by the work of Shelford on the Codling Moth.

It seems to me that, in our day and time, no laboratory or project can function efficiently without, at least, one or more recording instruments, more especially hygrothermographs. Recording raingauges and wind meters may not be quite as important, but their superiority to direct-reading instruments cannot be doubted. Completeness as to the number and kind of records to be taken is a more variable quantity. A good record of temperature, relative humidity and rainfall may be quite sufficient in the majority of cases. In fact, such a record may be considered essential in all work. Very often, a record of wind velocities is probably far more important than is generally conceded. Light intensities, whether referring to direct sunlight or diffused light may be significant enough in many cases, but their exact influence on the insects is often difficult to ascertain. Atmospheric pressure is subject to so many regular and irregular variations and its effect upon insects is, as yet, so obscure that the value of its record is very doubtful. Evaporation seems to be a favorite among the students of the influence of climate upon insects, but the results of its study often seem to be rather mysterious and intangible. Whilst these views may appear somewhat categorical, they are not set forth without considerable mental reservation. By way of recapitulation, the following may be considered as a tentative arrangement or list of the principal climatic factors in their order of relative importance.

1. Temperature and moisture (atmospheric humidity and precipitation).
2. Wind
3. Light (direct sunlight and diffused light)
4. Evaporation
5. Atmospheric pressure.

A record of all these may be desirable, but, where time or other circumstances impose limitations, the elimination process should begin from the bottom of the list upward.

If only one set of all or a part of the above records can be taken, it should be descriptive of the general climate of the region, that is to say it should be taken by standard methods and under standard conditions. It may be assumed that any variations or special conditions will be more or less proportionate to the prevailing influences in any area. This general record will permit comparison with conditions in other regions as recorded by special investigators or by the official meteorological stations. However, if a well equipped meteorological station be near at hand, the standard record for the region may be obtained from this station and the biologist will be well advised to use his own equipment to concentrate on the investigation of the special conditions relating directly to his problem. Every insect, every problem, every locality or habitat has its own peculiarities and requirements and the only suggestion that can be made in a general way is that it will pay to investigate every factor which it is possible to investigate and to be on guard against preconceived ideas. In work of this

kind, it is more than probable that much effort will be spent on phases which produce only negative results. It should be remembered that even such are worth while and that, moreover, with increasing experience or viewed from some other angle, or again, in the hands of other investigators, such negative results may yet become highly positive. In any event, we may safely assume that an accurate, continuous record of climatic factors for any locality especially, if it covers a period of years, has a scientific and practical value which is quite independent of any immediate application.

Before dismissing the subject of completeness, it should be made clear that several other records may be taken besides those indicated above, such as minimum on grass, dew point, visibility, temperature in the sun, cloud and solar radiation, etc. How far we should go in this matter, depends on circumstances which cannot be considered here, many of which will probably arise out of new developments in the course of future progress in this department of scientific research.

COMPARABLENESS

The word comparableness is used in a broad sense and, in many instances, implies correlation rather than mere comparison. As indicated in the introduction to this paper a certain meteorological record may be compared or correlated either with other meteorological data or with biological observations. To this end, it becomes necessary to analyse and classify the season's data by some system or another to be determined by the nature and requirements of the problem to be solved. In this procedure averages or means for periods of varying duration play an important part. In very accurate work it may be necessary to study certain fluctuations hour by hour, in other investigations comparisons by the day, the week or even the month will suffice. In hourly comparisons, actual readings are used rather than averages, because, as a rule, the fluctuations within a single hour or even within two hours are not large enough to necessitate the computation of the mean. Naturally, there may be exceptions. For longer intervals, in the majority of cases, the term of comparison is the mean value for the period. The daily mean is the one most commonly in use and forms the basis for the computation of weekly and monthly means.

Temperature

The daily mean may be defined as the mean of all the hourly temperatures from midnight to midnight, it is *not* the mean for any arbitrary sequence of twenty-four hours. The importance of this point as it affects the comparableness with other records need not be emphasized. The daily mean may be calculated in several ways. Geddes gives the following formula

$$\frac{1}{24}\left(a_1 + a_2 \ldots\ldots\ldots\ldots\ldots\ldots + a_{24} + \frac{1}{2}\left(a_0 - a_{24}\right)\right)$$

Where a_1 a_2 etc. are the hourly temperatures from hour 1 to hour 24, a_0 is the initial temperature at 0 hour.

Another method consists in measuring the area of the temperature graph by means of a planimeter and to divide the total so obtained by 24. The values may then be expressed in unit areas or converted into degrees temperature.

Either of the above methods will be found satisfactory, but presuppose, of course, the use of a thermograph. Where only ordinary registering (max. and min.) thermometers are available, the accuracy of the daily mean will depend upon the number of actual readings included in the computation. In some cases, the mean of the sum of maximum and minimum temperatures is considered sufficient, this, however, is very inaccurate and probably of little value in its application to biological phenomena. The more usual method includes one or more readings taken at regular intervals during the day. The procedure is mentioned here because many official records of the Weather Bureau are based on such calculations.

When only ordinary, non-registering thermometers are available some observers compute the daily mean from actual temperatures at certain chosen hours of the day. Thus, in Paris, it was found that the mean of the temperatures at 6 a. m., 1 p.m. and 9 p.m. is quite close to the mean obtained from the average of 24 hourly readings. As a matter of interest, I tested the method for the Ottawa district and found that the same set of readings as those used in Paris, worked more satisfactorily than any other combination.

Weekly means and monthly means are merely groupings of daily means. It will be found in practice, that for correlation with biological data such groupings are absolutely necessary, especially the weekly mean. For comparison with meteorological records taken in other seasons or other localities the monthly mean furnishes a very satisfactory basis. Probably the most useful application of the latter is the Ball-Taylor climograph or hythergraph. These considerations bring to mind another important concept, namely that of the average or normal climate of a region. It is of a statistical nature and is used in the study of irregular variations both as to time of occurrence and as to amplitude. It may be determined for hourly, daily, weekly or monthly periods. For example, the normal temperature for a given hour is the mean of the temperatures observed at that hour on a given day in the course of a number of years. The greater the number of years, the closer to the truth will be the value assigned. It should be the aim of every permanent biological station to ascertain more accurately, year by year, the normal values for the most important climatic factors such as temperature, rainfall and relative humidity for the region in which experiments are conducted.

Next or possibly equal in importance to averages, is the range or amplitude in oscillation of climatic factors. Thus, for temperature and relative humidity the daily, weekly and the monthly range should be calculated.

The daily range is the difference between the maximum and minimum reading.

The weekly range and monthly range are averages, namely the difference between the average maximum and minimum for the period. There is, of

course, an absolute maximum and minimum for such periods and it may be noted if it is thought to be particularly significant.

Some workers use ranges above and below certain more or less arbitrarily established bases. The particular value of this procedure is not clear to me, and its application is not of a sufficiently general character to warrant its discussion here.

Humidity

What has been said about records of temperature applies for the greater part to the records of relative humidity where recording instruments are used.

Rainfall

If a tipping bucket raingauge is available, both amount and intensity of rainfall are accurately measured and, furthermore, exact comparison with the daily temperature and relative humidity is possible. Rainfall is recorded in totals per hour or per day.

In the majority of cases, however, an ordinary standard raingauge is used and only total rainfall for the previous 24 hours is ascertained. Strictly speaking such a record is not correlatable to the standard temperature and relative humidity record, because it does not cover the same period. The usual procedure, in such cases, is to read the gauge at 9 a.m. hence the period is from 9 a.m. to 9 a.m., whilst in the recording of temperatures the period is from midnight to midnight. This point is often ignored by observers and it applies not only to precipitation but to any other factor in the study of which recording instruments are not used.

Wind

Wind is recorded by direction and in miles per hour, feet per minute or total miles per day.

Atmospheric pressure

From what has been said in the first part of this paper it seems likely that in connection with biological observations, a record of atmospheric pressure is useless unless a barograph be available. With a barograph it is possible to determine hours of maximum and minimum, amplitude of oscillations and any means per single period of oscillation or combination of such periods as may be desirable. On the whole, however, I am inclined to believe that it will merely result in a waste of time and effort.

Evaporation

Ordinarily, the totals per day or per week and the average per week or per month based on the daily total will fill most requirements.

Any discussion of comparableness of a meteorological record would, indeed, be incomplete without a word on uniformity or standardization of technique in recording and of methods of analysis. The fact that the usefulness of a good weather record for any locality is not limited by the confines of this locality need not be stressed. Usually such a record will contain two types of data, namely data peculiar to the problem in connection with which they are taken and data of a more general character, descriptive of the weather and climate of the region. The latter especially, if properly taken and analysed, should be extremely helpful both to the observer who collected them and to students of other problems for the comparison of conditions prevailing in regions removed from the study centre. A certain uniformity, therefore, in the number and kind of records taken, as well as in the presentation of the data so obtained becomes highly desirable. To arrive at this common standard the efforts of individual observers must be organized. In this connection, the co-operation of biologists and professional meteorologists is a prime requisite. This long-felt need prompted the convocation of the Empire Conference of Agricultural Meteorology about two years ago. As a result of this meeting, a number of important resolutions were adopted by the English biologists and meteorologists. A similar movement is on foot in Canada today. Committees have met, suggestions have been offered by various interested parties, the appointment of an official agricultural meteorologist has been urged, but so far, nothing of a definite nature has been achieved. The obstacles to efficient organization are as numerous and varied as the suggestions and opinions that have been expressed. In the meantime, whilst we wait for the final outcome of the movement, we must continue to make observations as systematically as we possibly can. Some of the general requirements for this work have been touched upon in the body of the present paper. It will be recognized that a considerable amount of what may be termed bookkeeping is involved in work of this kind. In the following some of the principal entries that may be made to advantage for each of the climatic factors discussed are suggested.

Temperature.—(Atmosphere or soil)

Daily: Maximum
Minimum
Mean
Range

Weekly: Maximum
Minimum
Mean

Range
Mean maximum
Mean minimum
Mean range
Monthly: Same data as weekly

Relative Humidity—Same data as for temperature.

Sunshine—Total hours per day
per week
per month
Averages as may be required.

Precipitation
a. Amount in inches or mm.: Daily total
Weekly total
Monthly total

b. Duration in minutes: Daily total
Weekly total
Monthly total

Wind—Daily: General:
Mean Direction
Total velocity
Special:
Direction and velocity at 9 a. m. 12m. and 6 p. m.

Barometric pressure:—
Daily: Morning maximum and minimum
Evening maximum and minimum.

Evaporation—
Daily: Total in cc.
Weekly: Total
Mean
Monthly: Total
Mean.

The combined action of temperature and humidity can most conveniently be expressed by the climograph or hythergraph method. At the present, the climograph or temperature-precipitation graph will probably prove to be most generally useful. It is hardly necessary to state that the graphic representation of many other data will be equally desirable.

The work of taking the records in the field is greatly simplified by the use of some specially prepared blank forms, of convenient size, on which all the records to be taken are tabulated.

It is my belief that a weather record prepared along the general lines proposed above is quite well adapted to the study of the response of insects

to climatic changes. The methods of taking biological observations which will be accurate, complete and comparable should form the next chapter in this study. It is hoped that the opportunity to write this chapter may present itself sooner or later.

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A MODIFICATION OF THE STOUGHTON CONSTANT TEMPERATURE-HUMIDITY CHAMBER

By J. R. G. Sutherland

Introduction

The need of an apparatus which will render possible the growing of plants for the rearing of insects in a controlled environment has long been felt. Unfortunately, relatively few attempts have, in the past, been made to devise such an apparatus, owing mainly, it would seem, to the expense involved. In the field of entomology at least, efforts in this direction have been confined to the construction of parasite rooms and other large-scale closets with thermal and hygral control. Very little attention has been paid to the development of an efficient, small chamber which would have a sufficiently low cost to make its employment in batteries of two or more feasible and within the range of a moderate appropriation.

Stoughton (1) describes the construction and operation of an apparatus which is used at the Rothamsted Experimental station for the production of a controlled environment in connection with studies in plant physiology. The apparatus of Stoughton fills, at least in part, the above-mentioned long-felt want.

Object

The apparatus of Stoughton is considerably more elaborate, and thus more expensive than is necessary for entomological work. Therefore it was undertaken to produce a constant temperature-humidity chamber, which though based in principle on that in operation at Rothamsted, would embody such alterations as were calculated to reduce the cost with a minimum sacrifice of efficiency.

The Apparatus

General.—Since the apparatus under consideration was to be used primarily for entomological purposes, the first step was to eliminate the soil-tank which had been found desirable for the complete control of plant environment in the chamber. The problem which then presented itself was to provide a small chamber with adequate thermal and hygral control at the minimum cost, and of the greatest possible simplicity.

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(1) Stoughton, R. H. Apparatus for the growing of plants in a controlled environment. — Ann. App. Biol. 17: 90, 1930.

The Chamber.—Three chambers were constructed measuring 4′ 6″ in length by 2′5″ in width by 3′7″ in height.

The frame (A) of each is of wood, and consists of a 2″ x 4″ bar along each edge of a cube of the above dimensions and, to increase the solidity of the structure, with a cross-bar (B) measuring 2″ x 4″ inserted horizontally in the centre of three of the sides and the top. The remaining side is occupied by two doors, each 1′9″ x 2′10″, involving the whole of the front of the chamber except the frame.

The frame is covered with sheets of triple-diamond glass (C) both inside and out, the glass being held in place by thin slats of wood mailed to the frame and to the cross-bars. The sheets of glass are spaced 2″ apart (D) by the bars, thus providing ample insulation from external temperatures.

Thermal Control.—The chambers are equipped with a heating apparatus and thermal regulators. Heat is provided by four, and in the case of that chamber which was designed for use at high temperatures eight, carbon filament heating bulbs (E) of the 250-watt type usually employed in electric grates. These bulbs are connected in parallel and the whole bank is in series with a De Khotinsky bimetallic spring thermo-regulator. The latter is so installed in the side-bar of the chamber that it is easily adjustable from the exterior by means of a knurled knob (F) while the spring (G) remains within the chamber at the temperature of the air in its interior.

Hygral Control.—(**a**) **Humidifier.**—Humid air is introduced into the chamber by means of a current of air passing over a carbon bulb (H) upon which water is dripping at a definite rate. The water is supplied from a large reservoir (I) placed on top of the chamber, and passes by way of a siphon (J) to the carbon bulb at its side. The siphon consists simply of 5mm. glass tubing drawn out to a fine tip or jet (K) at the lower end. A glass stop-cock (L) is inserted in the line for the purpose of regulating the speed of delivery at the jet.

The water which drops from the jet is evaporated from the surface of the carbon bulb (H) which is inserted in the bottom of a 7″ x 9″ metal can screwed to the side-bar of the chamber (M). The water jet projects through the top of the can to within $\frac{1}{4}$″ of the tip of the bulb. The bulb is swathed in a layer of muslin (N) from which a long strip is led through a small hole in the bottom of the can into a glass jar (O). The purpose of this strip is to conduct away any excess water which may accumulate during the time when the bulb is not burning, and by capillarity to keep the muslin surrounding the bulb from charring, should the amount of water dripping from the jet be slightly insufficient at any time.

The socket of the heater bulb is of the weather-proof type. To prevent

the penetration of water to its interior along the screw-threads of the base of the bulb, the latter is sealed in place with pliable roofing-cement.

A constant current of air is introduced at the side of the humidifier can 2″ (P) above the bulb by means of an air-line from a positive blower driven by a $\frac{1}{4}$ h. p. electric motor running at a speed of 1725 r.p.m. and consuming about 1.35 amperes. The blower and motor are on the market as a unit set-up, and were supplied by Messrs. The Central Scientific Co. An oil trap is provided in the air-line to stop any excess oil from the blower and to act as distributor in order that all chambers in operation may be supplied from a single blower. This is accomplished by the insertion of a glass T-tube in the neck of the oil-trap, to the arms of which are attached the air-lines leading to the individual chambers. See Plate II, Figure 2.

The humid air passes into the chamber from the humidifier can by means of a glass tube (Q) of 20mm. bore, 5″ long and flared at the outer end, which is placed diametrically opposite to the end of the air-line.

(b) **Hygrostat and Relay.**—The control of the amount of humidified air passing into the chamber is effected by a hair-hygrostat (R) operating a relay which in turn opens and closes the circuit on the heater-lamp within the humidifier can.

The hair-hygrostat consists of several strands of ether-treated human hair arranged vertically within a frame so as to move a platinum-tipped needle (S) on a dial mounted above, according as the relative humidity rises or falls. At each side of the needle is mounted a brass contact (T) which may be moved so as to come in contact with the needle at the desired humidity as registered on the dial. The contacts and the needle are in electrical connection with three binding-posts (U) at the periphery of the dial, and thus a closed circuit may be obtained through them at any desired point on either a rising or falling humidity. The hair-hygrostat was supplied by Messrs. Negretti and Zambra.

The needle and one brass contact are connected in series with the windings of a 3-ohm relay (V), a 15-ohm rheostat (W) a 16-candle power carbon-filament bulb (X), and the source of 220 volt direct current. The purpose of the carbon bulb is to furnish a supplementary resistance to that of the rheostat. For the sake of convenience these instruments are mounted on a 12″ x 9″ wooden base (Y) which is hung in the chamber. All connections are made by means of binding-posts (Z) in order that the control unit may be easily removed from the chamber if necessary.

By the adjustment of the rheostat a small current, about .05 amperes at 4-6 volts, is made to operate the relay when the cricuit is closed on the dial contacts. The armature (A′) of the relay bears a small brass contact-point as does the armature set-screw (B′). These are so connected that when they are in apposition they close a series-circuit comprising the source of 220-v.D.C. and

the heater-bulb of the humidifier. The complete circuit is given in Plate II, Figure 1.

Experimental Steps and Discussion

It would seem superfluous to give a full description of the apparatus as it embodied each of the various changes which were tested with a view to reducing expense and increasing efficiency, and then to describe the final arrangement of the parts. Since, in this way, much repetition would be involved, the account of the alterations which were effected from time to time is placed after, rather than before, the description of the final set-up. Further, it should be rendered more readily understandable by reference to the foregoing.

The device described by Stoughton for the control of the water issuing from the jet involves the construction of a glass tube drawn to a fine point over which is inverted a short sealed tube, the whole being fused into the water-line. Since such a device is not adjustable, a considerable number of such valves would have to be made in order to determine, by trial and error, the required number of drops per minute to produce the desired humidity. In view of this fact and that the services of a skilled glass-blower would be necessary in making the instrument, it was decided to attempt to substitute some simpler type of control.

A valve of similar principle was tested, using rubber-tubing in place of the glass for the water-lead. It was found to be inefficient because of the inability of the sealed glass gate to orient itself properly and constantly owing to the friction with the rubber lead. In addition, the tendency of the rubber tubing to deteriorate was the cause of discrimination against this type of water-line. Accordingly the siphon mentioned above was tested and found to be satisfactory.

Considerable difficulty was encountered from the blowing of fuses as a result of water from the humidifier penetrating the socket of the humidifier heater-bulb. Composition weatherproof sockets were substituted for the ordinary brass-shell in door type, and they, though lasting for a longer time, were still unsatisfactory. Therefore the heater-bulbs were sealed into their sockets by means of pliable roofing-cement, a method which was found to provide adequate protection from the water.

The introduction of humid air into the chamber was first attempted by means of a glass tube of the same bore as that conducting the air from the blower, viz. 7mm. In order to pass a sufficient volume of humid air from the humidifier can it was found necessary to increase the bore to 20mm. At the same time it was found advantageous to reduce the bore of the air-inlet tube to 4mm., in order to furnish a directional current of air over the heater-bulb.

Bulbs of various candle powers were tested to determine which would be most satisfactory as a source of heat in the humidifier. It was found that a

32 c. p. bulb was required to furnish sufficient heat for a relative humidity of 90 at 75 degrees F., while a 16-c.p. bulb was satisfactory for 90 at 60 degrees, or 60 at 75 degrees. For lower humidities at 60 degrees and above, and for higher humidities at 50 degrees and below, an 8-c.p. bulb was found to give good results.

It was found difficult to regulate the humidity by turning the heater-bulb off and on respectively above and below the desired percentage, since this results in a slight fluctuation of the temperature within the chamber, thus preventing the maintenance of as constant a relative humidity as would be desirable. As a remedy for this condition it was proposed to make and break the blower-circuit rather than that of the heater-bulb. When this was attempted it was found that there was considerable arcing at the points of the relay, resulting in their ultimate destruction. In some cases there developed a sufficient load on the power circuit to blow the fuses. In addition, such a plan of control would require the installation of a separate blower for each chamber.

Since such a method of regulating humidity would entail the use of oil-immersed points or of a mercury switch, as well as a blower for each chamber, it was abandoned as uneconomical. Nevertheless this or some similar plan of hygral control is the ideal, since it provides for the retention of a constant temperature at the point of desired humidity. For biological purposes the small range of variation shown by both temperature and relative humidity (*vide infra*) with the control methods now in use, is of no significance.

Stoughton describes the use of a storage-battery to furnish the current for the operation of the hygral control relay, the latter of the tilting-tube mercury type. In order to reduce expense, a 3-ohm relay bearing dry metal contact points on the armature was substituted for mercury type of instrument. In addition, the solenoid of the relay was connected in series with a variable and a fixed resistance and the 220-v.D.C. mains as described above, thus eliminating the storage-battery. The circuit which was developed for this purpose is given in Plate II, Figure 1.

As in the case of the apparatus of Stoughton, stratification of the air within the chamber was encountered. A maximum temperature variation of 6 degrees F. was found to exist between various points throughout the chamber, and a similar variation in relative humidity of 2% was noted. To overcome this condition, Stoughton has made use of a small fan operating continously. It was not found possible to install these fans a the time when the chambers were constructed.

Owing to the horizontal distribution of the temperature and humidity strata, their presence should not impair the efficiency of the apparatus where flats or pots of plants of the same height are to be used. However, if successive tiers of plants, or plants of various heights are under observation, it will be necessary to make provision for the prevention of these strata.

Calibration and Operation

To calibrate the hygrostat, it is set up vertically in a room, the relative humidity of which has been determined by means of a sling psychrometer. The needle on the dial is then adjusted to the correct reading by means of a small set-screw at the base of the frame. It may then be set up in the chamber. This process should be repeated at weekly intervals to insure the accurate operation of the instruments.

A preliminary adjustment of the stop-cock in the water-line is now made, until a delivery of from 20 to 30 drops per minute is obtained at the jet. After the operation of the apparatus has gone on for some time, it will be necessary to readjust the stop-cock until just enough water is passing the jet to prevent the muslin from charring and the humidifier from flooding.

One of the contact points on the hygrostat dial is set at the figure representing humidity. It was found most satisfactory to use the right-hand contact, breaking the circuit through the relay on a rising humidity, for high humidities. For low humidities, the use of the other contact gave better results. When the humidity in the chamber is sufficient to cause the needle on the hygrostat dial to come in contact with the brass contact, the rheostat is adjusted until a clean make and break is obtained at the armature points of the relay.

It will be necessary to determine by actual operation the size of carbon bulb to be used in the humidifier of each chamber. The chambers in operation at Macdonald College have been shown to run for long periods with a variation in temperature of not more than 2 degrees F. and in relative humidity of not more than 2%. The occurrence of a variation of this magnitude is not usual, if the apparatus be not subject to a very wide range of external temperature and humidity, but in any case is of little or no biological significance.

Summary

1. An account is given of a controlled temperature-humidity chambre modified from one in use at Rothamsted Experimental Station, and described by Stoughton, '30 (1).

2. An insulated chamber was sought, embodying efficient thermal and hygral control at the minimum expense.

3. The chamber consists of a wooden frame covered with two layers of glass, spaced 2″ apart by the bars of the frame.

4. Thermal regulation is supplied through the medium of four carbon-filament heater-bulbs in series with a DeKhotinsky electric thermostat.

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(1) Stoughton, R. H. Ann. App. Biol. 17: 90, 1930.

5. Humidified air is supplied by passing a stream of air from a positive blower over a carbon bulb on which water is dripping at a definite rate. The water is supplied by a reservoir and conducted to the tip of the heater-bulb by a siphon in which is installed a stop-cock. The bulb is situated in a metal can at the side of the chamber through which passes the air-stream into the chamber.

6. Hygral control is accomplished by connecting a hair-hygrostat in series with the solenoid of a relay, the points of which close the circuit on the humidifier bulb. The entire hygral control apparatus is operated from a single lead from the power mains.

7. The details of the steps in the construction of the apparatus are given, together with a discussion of its possibilities and limitations.

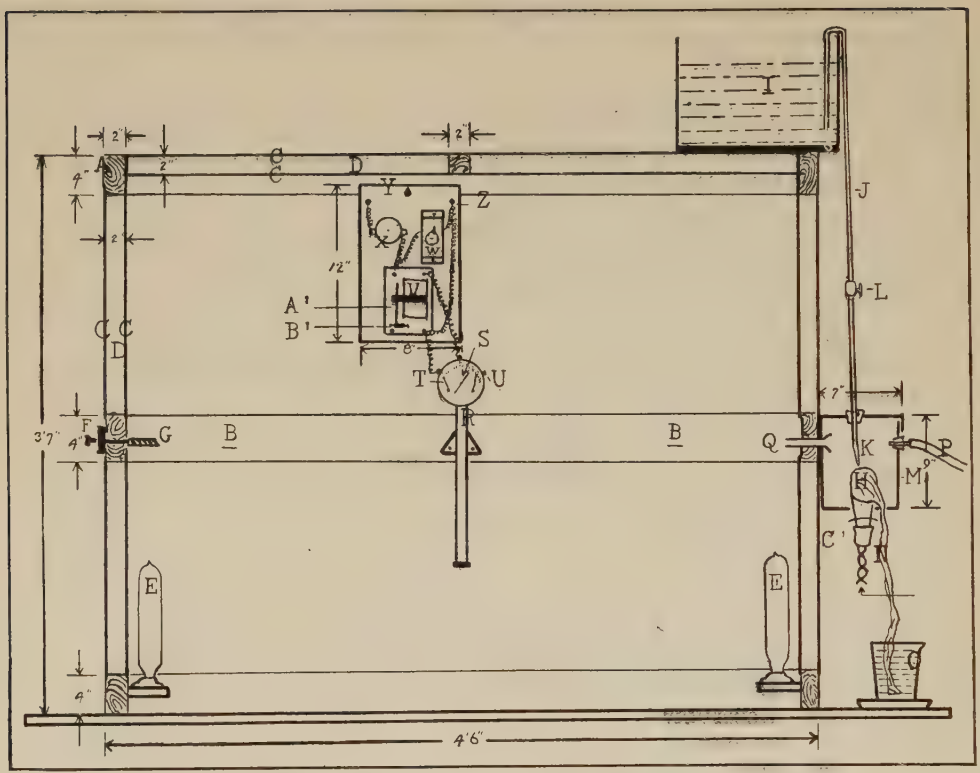
8. The method of calibrating the instruments and of operating the apparatus as a whole are outlined.

9. Three plates illustrate the details of construction and the efficiency of operation as shown by the hygrothermograph.

KEY TO PLATE I

A. Frame bar
B. Cross-bar
C. Glass
D. Air space
F. Thermostat adjustment knob
G. Thermostat bimetallic spring
H. Humidifier heater-bulb
I. Reservoir
J. Siphon
K. Jet
L. Stop-cock
M. Humidifier can
N. Muslin
O. Overflow jar
P. Air-line
Q. Humid air inlet
R. Hair Hygrostat
S. Hygrostat needle
T. Hygrostat contact
U. Hygrostat binding-posts
V. 3-ohm relay
W. 15-ohm rheostat
X. Fixed resistance (16-c.p. carbon bulb)
Y. Control board
Z. Control board binding-posts
A′. Armature of relay
B′. Set-screw of armature
C′. Waterproof packing.

PLATE I



Diagramatic Vertical Longitudinal Section of Constant Temperature — Humidity Chamber, Showing Form and Arrangement of Instruments.

PLATE II

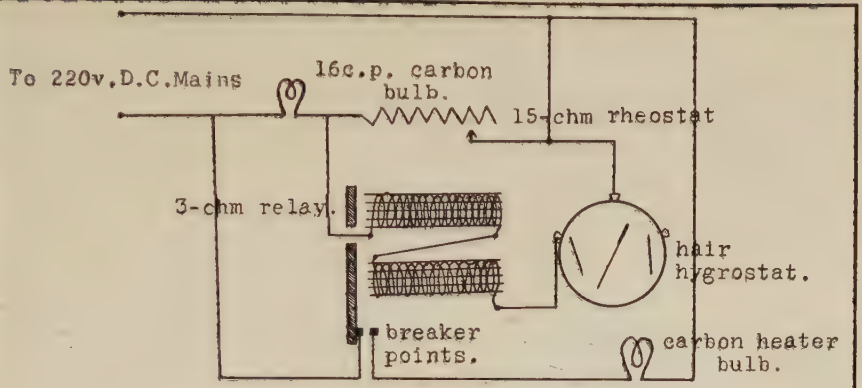


FIG.1--Hygral Control Circuit.

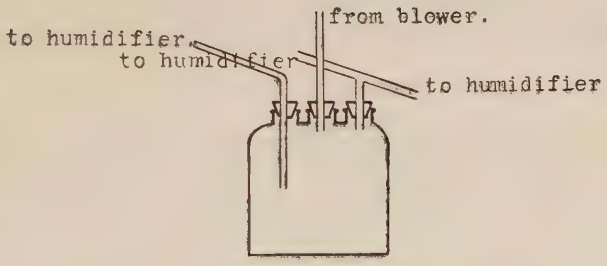


FIG.2--Oil-trap and Air Distributor.

PLATE III.—Thermohygrograph records of the performance of the chambers.

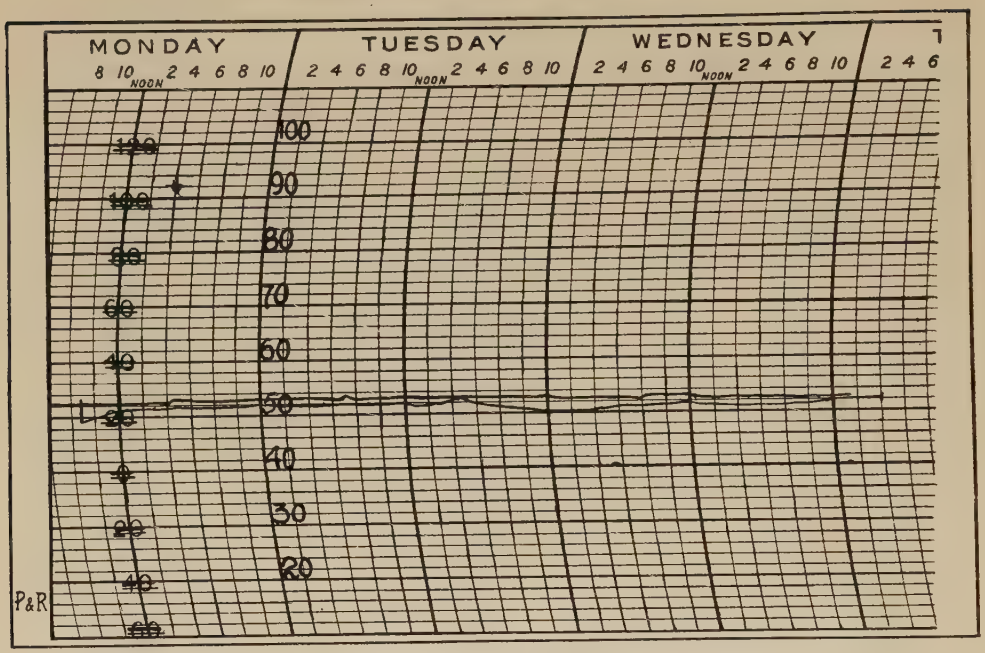


Fig. 1—Low temperature and low humidity,—52° F. & 51 R. H.

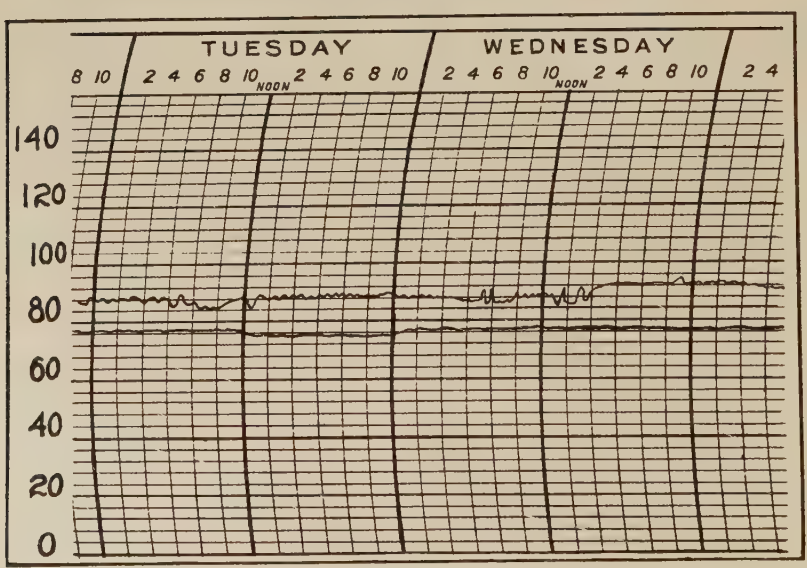


Fig. 2—High temperature and high humidity, — 76° F. & 84 – 92% R. H.

NOTE :—Temperatures and humidities are to be read from the figures at the left of the charts.

THE GRAPE MEALYBUG (Pseudococcus maritimus Ehrhorn)

ORDER: Homoptera. FAMILY: Coccidae,

Wm. Dickison

Introduction

Two species of mealybugs are commonly reported from greenhouses in Canada, namely, *Pseudococcus citri* Risso and *P.longispinus* Targ. While undertaking certain biological studies with a species occurring in the biological greenhouse at Macdonald College during the winter of 1929-30, it was noted that the species under study did not seem to agree with the published descriptions of either of the foregoing species. Thus, specimens were forwarded to Prof. G. F. Ferris and were determined as *Pseudococcus maritimus* Ehrhorn.

It seemed advisable with this information to determine the distribution of the species in greenhouses in Canada, and accordingly numerous collections were obtained from various parts of Ontario and Quebec. The survey was made during the months of May and June.

It is significant to note that no specimens of *P. citri* Risso or *P. longispinus* Targ. occured in the collections. Thus it would appear that a species not heretofore reported is common in the greenhouses of central Canada, whereas neither of the species said to be common were obtained from greenhouses covering this area.

History

The Grape Mealybug (*P. maritimus*) is known to have existed in the southern part of California as early as 1898 (17), but not until 1900 did Ehrhorn (1) describe this species, finding its presence on the roots of *Erigonum latifolium* on the cliffs at Santa Cruz, California. During the year 1909 this insect was found to be doing commercial damage to the grape industry in a few scattered sections of Fresno County (15). Its spread was rapid, especially in California, and within a period of ten years it spread to the Counties of Tulare, Kings, Madera, San Joaquin, Merced, Stanislaus and Orange, causing severe damage wherever it became established. Hollinger (22) in 1917 found it present in the State of Missouri, and in 1918 it was reported from the State of New York where it was noticed in a few scattered greenhouses. During the following year Chaffin recorded it near Key West, Florida, and in the year 1921 it was known to be present throughout the United States, its damage being most important in the States of California, Michigan and Missouri. It was not until the year 1919 that it was detected outside the United States, but in this year Green (25) obtained specimens from greenhouses in England.

Its presence in Canada has not yet been reported, as far as the writer is aware, but it is safe to say that it has been distributed throughout the eastern provinces for some time and possibly has been confused with one or other of the two species commonly reported from these provinces.

Host plants

The insect has been found to thrive on over eighty host plants. In Canada, however, it has only been observed on Coleus, Geranium, Grotum, Hydrangia, Palms, Poinsettia and the Rose.

Injury

The Grape Mealybug injury in Canada is a detriment to lucrative business, causing an unsightly appearance to plants offered for sale, and disappointment to the purchaser when the insect develops on a plant which, when purchased, was apparently clean and healthy. Injury to the plants from the physiological point of view is hard to detect from casual observation, but in cases where the insect has increased to large numbers the leaves may yellow and the petals of the flowers drop.

Synonomy

Before the year 1917 the classification of the genus *Pseudococcus* was inadequate, since the legs and antennae—the characters used in classification—varied greatly within species. However, with the introduction of such characters as the anal ring, cerrari and caudal spines many species were found to have been confused with other existing forms. The 'summer forms' of *P. trifolii* mentioned by Davis in 1894 are, no doubt, *P. maritimus* (9), but since no adequate description accompanies the report the synonomy becomes—

1900—*Dactylopius maritimus* Ehrhorn,
Can. Entom. 32: p. 315.
1909—*Pseudococcus obscurus* Essig,
Pomona Col. Jn. Ent. 1: p. 43.
1909—*Pseudococcus bakeri*, Essig,
Ibid 2: p. 334.
1917—*Pseudococcus omniverae* Hollinger,
Ann. Ent. Soc. Am. 10: p. 271.

Description of Stages (Pseudococcus maritimus Ehrhorn)

Eggs:—Elliptical-oval, pale orange yellow in colour. Length, 0.45 mm.; width, 0.328 mm. Contained within a white mass of silky threads termed ovisac or egg-sac.

Before first molt and less than 24 hours old—Body elongate and oval, list orange colour, no filamentous secretions on margin of insect. Antennae 8-jonted and noticeably hairy. Length, 1.67 mm.; width, .67 mm. Male and female indistinguishable.

Female

After first molt and 20 days old—Body elongate and oval, medium orange in colour, filamentous secretions commencing. Length 2.23 mm.; width, 1.17 mm.

After second molt and 32 days old—Orange yellowish colour, fine evenly distributed waxy white secretions and marginal filaments of a like nature resembling coarse white threads; caudal filaments slightly longer than marginal filaments. Length 3.19 mm.; width 1.73 mm.

Adult female—Marginal filaments about $\frac{1}{3}$ as long as insect in wide, except four at caudal end, two of which are $\frac{3}{4}$ as long as the insect. Length 4.71 mm.; width 2.83 mm.

Note:—Laying females become wider and shorter and do not conform with description above.

Anal cerari with numerous tricerores crowded into a circular area about the ceraran setæ; seventeen pairs of cerari, all cerari with numerous auxillary setae; anal setæ shorter and more slender than anal ring setæ; cisanal setæ farther apart than obanal setæ.

Male

After first molt—Rostralis absent, legs and antennae, and the wing-pads also absent; enclosed in waxen secretion.

After second molt—Vestigial wing-pads, legs and antennae appear as sacs; enclosed in cocoon. Length, 1.14 mm.

After third molt—Antennae and legs movable, wing-pads further enlarged; head, thorax and abdomen resemble adult. Length 1.28 mm.

After fourth molt—Fragile; 1 pair of delicate wings, halteres small and hooked; legs free; eyes simple, on dorsal and lateral side of head, the latter $\frac{1}{2}$ size of former; mouth-parts absent; 2 large caudal filaments longer than length of body; also small medial pair. Length 1.67 mm.

LIFE HISTORY

Temperature: Average 67° F.

Female—Average length of life 87.4 days

Stage	No. individuals	Minimum	Maximum	Average
		days	days	days
Egg	120	11	14.5	13.2
1st Stage	30	12	17	14.9
2nd Stage	30	9	14	12.5
3rd Stage	23	14	16	15.7
Adult	17	25	36	31.1

Male—Average length of life 47.5 days

Stage	No. individuals	Minimum	Maximum	Average
		days	days	days
Egg	120	11	14.5	13.2
1st Stage	30	12	17	14.9
2nd Stage	12	5.3	8.5	7.4
3rd Stage	12	3.8	4.0	3.8
4th Stage	12	3	5	4.2
Adult	24	1	6	4.0

Life History

The eggs of the Grape Mealybug are deposited in an ovisac or waxy secretion which is white in colour, and this ovisac enlarges as the number of eggs deposited increases. The period of preoviposition of the female is roughly from ten to fourteen days, while oviposition may last for at least two weeks. It is claimed by some that this species may lay 600 eggs, but of fifteen ovisacs examined by the writer an average of only 231 eggs was obtained.

The larvae on hatching remain in the ovisac for a day or two, and on emerging from the sac usually move upwards and outwards, thus reaching the tender tissues of the leaves. Here they feed, moving only occasionally, and then but for small distances. The second stage larvae show a greater tendency to migrate. It might be said that ants may form an important factor in the transportation of the insect from unhealthy to healthy plants. Towards the end of the second stage the insect settles down, usually in the axil of a leaf, branch or stem, inserts its beak and commences feeding. The position chosen is usually a permanent one, but an older individual will seek a better feeding ground if necessary.

The time of mating varies; females have been noticed to mate seven to sixteen days after the third molt, depending mainly on the presence or absence of males. I might mention that ten females were apparently deprived of the presence of males and of this number seven laid eggs. These eggs hatched, but unfortunately the writer does not deem the results conclusive enough to say that *P. maritimus* may be parthenogenetic in the absence of males.

The metamorphosis of the male differs from that of the female in certain respects. Male and female cannot be distinguished during the first instar. During the second instar the male larva seeks out a spot of seclusion, usually the under side of a leaf, along the mid-rib or around the base of a plant or flowerpot, forms its silken pupal case and undergoes a transformation. If disturbed

during the fourth instar, they are capable of moving rapidly, and if their spot of seclusion is sufficiently protected from light, they are capable of reaching maturity.

After the last molt the mouth parts are lost, two well developed eyes appear, and the wings are large and membranous. The insect on emerging from its silken case rests for a few hours, runs hurriedly over the leaf, stem or pot for an hour or so, then takes to flight. Its migration from plant to plant may be a very slow one and if mature females are abundant on the plant on which it emerges, it may never leave its radius. In an endeavour to determine the possible length of the life of a male, 24 individuals were placed in a cage containing a plant. Life may persist from one to six days, but an average of four days was obtained for sixteen individuals.

Control

Considerable effort has been applied ever since the mealybug became a serious pest with the object of finding a means of control. Sprays and fumigation have been resorted to, but the success has been but slight. In Canada, methods which are commonly employed by the growers to protect their plants are chiefly:

(1) The plants are washed in a solution of soap and water, to which in some cases nicotine has been added. The plants are individually sponged with this solution, and an endeavour is made to clean each leaf, stem or branch with the solution. Control may be obtained but for a short time, as only the laying females are removed, and the young larvae and eggs remain immune to the treatment. To be successful, treatments would have to be applied every three weeks, a procedure which no grower could consider.

(2) The application of alcohol by means of a paint brush, placing a small drop on each individual apparent, has been adopted by a few growers who grow the plants as a hobby. The success of this treatment lies in the fact that the adults, eggs and third instar larvae are killed, but to obtain the maximum control the plants must again be treated each month.

(3) If the plants be roses, hydrangeas, or similar plants capable of withstanding water under high pressure, this treatment is usually effective. This control, however, is only of a checking nature, and within two months the insect will be as numerous as it was before treatment.

It is well to note that certain growers claim to be receiving success by the application of an oil emulsion, but at present the results are controversial. It can be readily seen that the methods which are adopted are not only laborious but time consuming, and owing to these important factors many growers find it unprofitable to consider such control measures.

The following are the properties which a chemical control should possess to be effective against the Mealybug:

(1) A solvent which will penetrate the waxy secretion of the insect.
(2) It must be a contact poison.
(3) It must have the power to penetrate the egg mass.

(4) It must be able to penetrate the cracks and crevices of the bark and joints.
(5) It must not only kill certain stages of the life history, but must, since the life history overlaps, be destructive to all stages.

Conclusion

In conclusion, might I tabulate the points which appear to be of paramount importance or of interest as far as the insect is concerned in Canada:

(1) What are the boundaries of the insect, and what closely allied species are present?
(2) Will the insect survive the winter in any part of Canada?
(3) Can the insect be eradicated by the hardening off of plants?
(4) Are the females parthenogenetic in the absence of males?
(5) Is biological control applicable in greenhouses?

Part B.—Additions to the genus Pseudococcus in Canada

Introduction

The object of this paper is to report the findings of a preliminary survey made to determine the species of the genus *Pseudococcus* in Canada. The survey was made possible through the interest of the Dominion Entomological Branch of Canada which collected the greater portion of the material identified. The writer wishes to stress that the survey is by no means complete, but, it shows that certain species of the genus *Pseudococcus* hitherto unrecorded are present in Canada.

The number of separate collections obtained and the provinces from which the collections were made is shown in the following table:

Province	British Columbia	Manitoba	Ontario	Quebec
Lots (number of)	2	2	34	11

Five species of *Pseudococcus* were obtained, namely *aurilanatus*, *timberlakei*, *citri*, *maritimus* and *comstocki*. *Maritimus* was by far the most prevalent species, *citri* and *timberlakei*, *comstocki* and *aurilanatus* occurring in but small numbers.

Key to the Species

Anal lobe cerarii of these species has not more than two cerarian spines.

A. With no auxillary setae in the cerarii anterior to the last two abdominal pairs.
B. With no definite cerarii anterior to the 5-6 abdominal segments. *aurilanatus* (Mask).

B.B. With cerarii on the head and thorax.
C. With a large, well defined chitinized area surrounding anal cerarii. *timberlakei* (Ckll.)
C.C. Without a definite chitinized area about the anal cerarii. *citri* (Risso)
A.A. With auxillary setae in the cerarii anterior to the last two abdominal pairs.
B. Pores of the anal lobe cerarii arranged in a crowded circular group. *maritimus* (Ehrh).
B.B. Pores of the anal lobe cerarii scattered. *comstocki* (Kuw).

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SOME OBSERVATIONS ON THE COMMON MEALYBUG, *Pseudococcus citri* Risso

KEL

By J. R. G. Sutherland

Introduction

The common mealybug, *Pseudococcus citri* Risso is a pest of considerable importance to greenhouse owners in the temperate regions, and to citrus-growers in the subtropics. Plants infested by this pest may become not only unsaleable because of the unsightly wax secretions, but also stunted and unthrifty owing to the feeding activities of the insect.

The common mealybug has been reported from all parts of Canada since the '60's of the last century; it is known to be practically cosmopolitan in distribution at the present time. Its native habitat is the citrus groves of the Mediterranean area, where it was described more than a century ago and had been recorded for many years previous to that date. *P. citri* is found on a wide variety of hosts, and in environments differing greatly from each other. In the temperate regions the insect is primarily a greenhouse pest, although outbreaks have been occasionally recorded as occurring out of doors during the summer months. In the biological greenhouse at Macdonald College, *P. citri* was observed on on *Coleus, Capsicum, Poinsettia,* and wheat.

It is interesting to note that in the winter of 1930-31 *P. maritimus* and *P. aurilanatus* were the only species observed in the above-mentioned greenhouse, while during the winter of 1931-32, *P. citri* alone was recorded as present.

Object.—These studies were undertaken to determine the details of the life history of *P. citri*, as regards the structure and behavior of the various stages under conditions which were as nearly as possible similar to those maintained in commercial greenhouses in the ordinary course of events.

Methods.—Ten adult female *P. citri* were placed upon uninfested Coleus plants and allowed to oviposit. Two hundred eggs were then placed individually upon separate leaves of plants of the same species, and placed in the greenhouse for observation. Owing to the wandering habits of the newly-hatched nymphs, it was impossible to keep separate the various individuals and hence this method was discarded as unsatisfactory.

Two hundred newly-laid eggs were then placed singly on Coleus leaves by means of a camel's-hair brush, and each leaf placed in a petri-dish containing about one half inch of water. This method was more satisfactory than the one previously employed, but owing to the nearly horizontal position of the leaves, the nymphs developed a marked tendency to drown themselves during moulting. In addition, the plates required an excess of space.

The duration of the egg-stage was determined by the above methods. In order to save time, and to eliminate the drawbacks mentioned, newly-

hatched nymphs were now placed by means of a small scalpel, to which they were found to cling readily, upon individual leaves standing vertically in 3″ shell-vials each containing about ¼″ of water. The duration of the instars was determined by observing the presence of exuviae which were found to adhere readily to the leaves by the wax coating.

In this set of observations the nymphal mortality was still high, but was attributable in most cases to normal first-instar mortality rather than to drowning.

Observations of the condition and development of the insects were taken daily, and the results of these observations are given below. Concurrently with the vial tests, other individuals were observed on Coleus plants under greenhouse conditions and the habits of the instars and total length of life-cycle checked against the notes on the individuals in the vials.

During the time when the various observations were being taken on the insects in the greenhouse, the temperature was kept as nearly as possible constant at 68 degrees Fahrenheit. The other groups of insects were run in a constant temperature chamber at 70 degrees Fahrenheit, and 79-84% R. H.

It was found necessary to replace the leaves in the vials once in about seven days, even if they had been severed from the plant while under water. Later, it was found that the leaves could be kept fresh for a much longer time by removing with each a small part of the stem bearing a bud, much as in the usual procedure in the propagation of Coleus by cuttings. When this was done, adventitious roots were produced at the base of the petiole, resulting in the prevention of the progressive wilt and rot which ordinarily occurred under these conditions.

Mounting Technique.—Great difficulty was encountered in removing the contents of the mealybugs for microscopical study by the usual hot or cold potash methods. The cold potash method requires several days for the completion of the clarifying process, while the hot method may easily result in extreme fragility of the integument and in the distortion of the appendages if used by any but an experienced technician. With both these methods it is necessary to remove by puncturing the body all the fat-globules remaining in it after treatment. This involves increased handling of the insect with its attendant hazards.

Accordingly a method was developed to overcome this difficulty. The specimens were placed in a vial containing about one quarter-inch of 10% potassium hydroxide in the bottom. The vial was then filled to within a short distance of the top with ethyl ether, corked and placed in a constant temperature chamber at about 50 degrees Centigrade. After two to three hours, first and second instar nymphs were completely clarified, third instars requiring six to eight hours and adults ten to twelve as a rule. In the case of adults and of particularly obstinate third instar specimens it was found necessary to

replace the ether which had evaporated after about six hours. The use of this method eliminates the necessity of grasping the specimens in forceps or of squeezing them at any time throughout the whole procedure, removal of the insects from one fluid to another being accomplished by enclosing them in a drop picked up between the point of a pair of forceps, the forceps not actually touching the specimens at any time.

The stain used was acid fuchsin, .4%. The length of time require for satisfactory staining varied considerably with the instars and with the condition of the specimens, and will be best determined by trial and error at the time the work is done. Very small or delicate specimens were found to benefit considerably from hardening in alcohol for a short period previous to staining. It is imperative that the specimens be thoroughly washed before staining, lest any traces of KOH should remove the acid stain after mounting.

The insects were brought up through graded alcohols and mounted in thin xylol-balsam in the usual manner. Adult males were run up without clarifying and staining owing to the tendency of the comparatively large wings to become badly tangled after subjection to the KOH. Eggs and exuviae were not stained but were simply brought through the alcohols and carbol-xylol and mounted in balsam.

Life History and Description of Stages.—The eggs are .25 to .4 mm. long and .09 to .12 mm. in width. They are cylindrical in shape with rounded ends, bright yellow when freshly laid, and turn slightly darker just prior to hatching. The chorion is delicately reticulated with a polygonal pattern. They are laid in an "ovisac" consisting of fine threads of wax secreted by cerores at the caudal end of the body of the female. Varying numbers of eggs were found in the ovisacs of various females, ranging from 42 to 361, with an average of 172. The eggs hatch in from 9 to 15 days, the average duration of the incubation period being 11.2 days.—Pl. I, Fig. 1.

First instar.—Mounted specimens:—Length, .3 to .5 mm.; antennae six-jointed, 120 to 170 microns long, the average being 150 microns; tibiae stout, the sides curved, shorter than or subequal to the tarsi in length, from 40 to 80 microns long with an average of 55 microns. It may here be mentioned that Smith (9) does not consider such measurements as valid criteria for species determinations, and from a comparison of the foregoing figures with those below it would seem that the principle also applies to the separation of instars.

The other characters of the mounted and of the living specimen are, except for size and colour, similar to the respective characters of the adult female.

Hatching is accomplished by bursting one end of the egg-chorion. When recently hatched, the nymphs are comparatively inactive, remaining in the ovisac for a period of from ten to twenty-four hours. While in the ovisac there is

little movement from place to place, motion being confined to feeble leg-spasms and a nervous twitching of the antennae, the latter persisting throughout the greater part of the instar, though most marked while the nymphs are still in the ovisac. At ten hours and upwards the nymphs become restless and leave the ovisac to seek a feeding-place. Coincident with this movement the colour is gradually changing from the reddish brown of hatching time to a varnished lemon yellow against which the drak-pigmented eyes are more conspicuous. Early in the instar the dorsal cerores become active, to be followed shortly by activity of the caudal cerores. The colour gradually becomes darker in the last day or two of the instar until a brownish tinge has been assumed just prior to moulting.

Moulting is accomplished by the production of a transverse suture in the cephalic region and a longitudinal one extending down the dorsum. The average duration of the instar under the above-mentioned conditions was 13.1 days.—Pl. I, Fig. 3.

Second instar Female.—Mounted specimens:—Length, .6 to .8 mm.; antennae six-jointed, 180 to 220 microns long, the average being 200 microns; tibiae short, stout, the sides curved, subequal to or slightly longer than the tarsi, hind tibiae from 80 to 100 microns in length, averaging 85 microns.

The other characters of the mounted and of the living specimen are, except for size and colour, similar to those of the adult female in the respective conditions.

This instar is the first in which the males and females may be separated with certainty, the former losing the rostrum at the first moult. Early in the instar the nymphs are the colour of dried orange shellac, becoming varnished lemon yellow after forty-eight to seventy-two hours and again darker shortly before the second ecdysis. In this stage the nymphs tend to be rather sedentary in habit, seeking out axils of leaves and veins, and there feeding with only occasional moves throughout the instar. However, they move quite rapidly for short distances if disturbed. The dorsal and caudal cerores become active shortly after the second ecdysis, and the lateral cerores somewhat later. The average duration of the instar was 13.0 days.—Pl. I, Fig. 7.

Third instar Female.—Mounted specimens:—Length, 8. to 1.5 mm., antennae seven-jointed, 370 to 450 microns long, the average being 420 microns; tibiae varying from stout to slender and elongate, the sides curved or straight and parallel, hind tibiae distinctly longer than the tarsi, measuring from 160 to 230 microns in length with an average of 190 microns.

The other characters of the mounted and of the living specimens are, except for size and colour, similar to those of the adult female in the respective conditions.

At the beginning of the instar the nymphs are clay yellow, becoming light lemon yellow with a fleshy tinge after about forty-eight hours, and then assum-

ing a purplish tinge during the last two or three days of the instar. Early in the instar the nymphs are relatively inactive, continuing to feed in the axils of leaves and veins as in the second instar, but toward the end they become more restless and move about to a considerable extent. All the cerores become active in the first few hours of the instar, furnishing the nymphs with a wax coating similar to that of the adult.

Several individuals of the third instar were observed to pass below the water level in the vials in one of the groups under observgtion. One individual lived for 77 days in this condition, though in this and all other similar cases no moulting took place after immersion in the water. The average duration of the instar was 11.7 days.—Pl. I, Fig. 9.

Adult Female.—*Mounted specimens:*—Length, 1.25 to 3 mm. Shape, elongate-ovoid to sub-rectangular with the corners rounded, the segmentation well-defined on the abdomen, less so cephalad. The antennae are eight-jointed, articulated to the ventral aspect of the head near the lateral margin, 400 to 510 microns long, averaging 445 microns. The eyes are small, inconspicuous, containing a dark or black pigment, and situated on the lateral margins of the head, somewhat ventrad of and posterior to the antennae. The rostrum is a conspicuous structure, extending for about one third the length of the body, and with a delicate sub-triangular crumena posterior to its base. The legs are present throughout the stage; the tibiae are distinctly more than twice as long as the tarsi, slender, and with the sides parallel; the hind tibiae measured 230 to 290 microns, averaging 256 microns. The tarsal claws each bear a curved, flattened seta-like process. There are eighteen pairs of lateral cerarii, including those on the anal lobes. The anal lobe cerarii bear auxilliary setae, while the others are usually though not always without them. Two cerarian spines are borne by each cerarius, except in the case of the anterior three or four which may bear two to four spines. The cerarian spines are fairly stout, and of medium length, those of the anal lobes being larger than any of the others.

None of the cerarii are surrounded by distinctly sclerotized areas, the tricerores of the anal pair relatively large and few in number, of the other pairs somewhat smaller and variable in number but never numerous. The ventral surface of each of the anal lobes bears an oblique sclerotized strip extending mesocephalad from the bases of the anal lobe setae. There are two anal lobe setae and six anal ring setae, the former about twice as long as the latter, or even more in some specimens. The dorsal body setae are rather sparse, fairly large and stout; the ventral body setae are similar in form and numbers.

Living specimens:—The aduts are clay yellow in colour at the beginning of the stage, becoming gradually darker until a light purple madder colour is attained; the colour throughout the whole instar is modified by the presence of the reddish body contents. Throughout their lives the adults are relatively sedentary unless disturbed, but move for short distances from time to time in

search of a new place to feed. They prefer the undersides of leaves, the petioles and stems, and are often found congregating in groups of five or six or more in the axils of leaves. Growth continues during the adult stage due to the increase in size of the ovaries, resulting in a change in body form from elongate and scale-like to short oval and rotund.

Secretion of wax from the dorsal and lateral cerores commences at the completion of the third ecdysis, and from the cerores of the anal area at the inception of oviposition. Egg-laying begins on an average 14.4 days after reaching the adult stage. The secretion of the ovisac, which is composed of tangled threads of fine-spun wax, is practically synchronous with the deposition of the eggs. The adults observed laid an average of 172 eggs over an average period of 10.8 days. If during the process of oviposition the females were disturbed, they usually moved to a more quiet place and there started a new ovisac.

Four third instar females were confined in corked bottles and prevented from mating. They lived on an average 10.6 days after having attained the adult stage, but in no case did they lay viable eggs. One, which lived as an adult for 13 days, laid seventeen eggs none of which hatched.—Pl. I, Fig. 5.

TABLE I.—Life Cycle Summary of P. citri (Female) *

Stage	Number of specimens	Maximum	Minimum	Average
		days	days	days
Egg	177	15	9	11.2
1st instar	61	17	10	13.1
2nd instar	22	14	11	13.0
3rd instar	14	13	11	11.7
Adult	14	28	24	25.2
Preoviposition, period	14	17	13	14.4
Eggs, Number of	20	361	42	172.
Total		81	62	74.2

* Temperature 68 to 71 degrees Fahrenheit.

First instar Male.—The males in this stage are indistinguishable from females of the same stage in form and habit, except in mounted specimens which are approaching the first ecdysis, when the absence of the mouth-parts of the developing second instar within may be noted.

Second instar Male.—*Mounted specimens:*—Length .7 to 1mm.; somewhat more slender and elongate in outline than the female nymph of the same instar; rostrum absent; in other respects similar to the second instar female.

Living specimens:—Body covered with rather coarser wax than in the case of the other instars, varnished gamboge to pale brown or olivaceous in colour. The antennae are carried free from the side margins of the thorax and the wing pads are not visible. The nymphs are active at the first of the instar, but after about five days seek out sheltered spots such as the axils of leaves, earth or debris in the pot, or the rim of the pot itself and there spin cocoons of delicate wax threads. Here the nymphs remain quiescent until the adult stage is reached, pushing the exuviae to the end of the cocoon at the end of each instar. Average duration of stage 7.5 days.

Third instar Male.—*Mounted specimens:*—Length .8 to 1mm.; body elongate-oval to sub-rectangular; antennae seven-jointed, ranging in length from 210 to 240 microns, with an average of 213 microns, rather stout, filiform; one pair of lateral ocellana present, just posterior to the bases of the antennae. The wings pads appear as short sac-like evaginations of the thorax. The tibiae are stout, somewhat curved and subequal in length to the tarsi; the hind tibiae range in length from 70 to 80 microns, averaging 77 microns. The anal setae are subequal in length to the last abdominal segment.—Pl. II, Fig. 2.

Living specimens:—Body elongate, subcylindrical, finely covered with wax and pale brown with an olivaceous tinge to gamboge in colour. Throughout the stage they are quiescent within the cocoon, though they move if disturbed. The antennae are held closely along the sides of the thorax and are incapable of movement. The eyes are distinctly darker than the body but are not prominent. The wing-pads are barely noticeable as swellings on the lateral margins of the thorax. Average duration of stage 4.7 days.

Fourth instar Male.—*Mounted specimens:*—Length .9 to 1.2 mm., body fusiform. The antennae are eight-jointed, ranging in length from 390 to 470 microns, averaging 420 microns, rather stout, filiform. The eyes consist of three pairs of ocellana, one pair dorsal and posterior to the bases of the antennae, one ventral in the position occupied in the female by the mouth-parts, and one lateral about the centre of the side of the head. The dorsal and ventral eyes are subequal in size, while the lateral pair are smaller. The wing-pads extend to the fourth abdominal segment. The tibiae are short, stout and curved but distinctly longer than the tarsi; the hind tibiae are 140 to 160 mircons in length, averaging 150 microns. The anal setae are slender and subequal in length to the last two abdominal segments.—Pl. II, Fig. 3.

Living specimens:—Body elongate, somewhat fusiform ranging from Van Dyke brown early in the instar to burnt sienna or lighter and often with an olive tinge late in the instar. The antennae are carried close to the sides of the thorax. There are six eyes, distinctly darker than the body in colour. The wing-pads are about half the length of the abdomen. During the instar the nymphs remain quiescent in the cocoon, but move if disturbed. Duration of stage, (avge.) 4.0 days.

Adult Male.—*Mounted specimens:*—Length .9 to 1.1 mm., body elongate-fusiform. Antennae slender, filiform, nine-jointed, ranging in length from 630 to 700 microns with an average of 653 microns. The eyes are as in the fourth instar male. The wings are elongate oval in shape, with subcosta much reduced and radius and media present but unbranched. They vary in length from 1100 to 1250 microns, averaging 1150 microns. The halteres bear a relatively broad knob at the end of a slender stalk, surmounted by a curved or hooked seta-like process. The tibiae are slender, more than twice as long as the tarsi; the hind tibiae vary in length from 250 to 310 microns, averaging 276 microns. The anal setae are subequal in length to the entire abdomen. The stylus is short, stout and inconspicuous.—Pl. II, Fig. 1.

Living specimens:—Body elongate, subcylindrical, narrowed somewhat cephalad and caudad, covered with fine grains of wax, and ranging in colour from burnt sienna to olivaceous. The thorax is darker than the rest of the body, being a dark ashy gray colour, or almost black.

The antennae are rather slender, filiform, and about two-thirds as long as the body. They are held at right angles to the long axis of the head. The wings are delicate, elongate-oval, smoke coloured and about twice as long as the abdomen. The abdomen bears at its caudal end two long, moderately slender and conspicuous white filaments of wax. There are three pairs of dark-reddish eyes arranged as in the fourth instar male nymph.

The adults remain in the cocoon for about twenty-four hours after the completion of the fourth ecdysis and then emerge to seek out the females for mating. The average length of life was found to be 5.2 days.

TABLE II.—Life Cycle Summary of P. citri (Male)

Stage	Number of specimens	Maximum	Minimum	Average
		days	days	days
Egg	177	15	9	11.2
1st instar	61	17	10	13.1
2nd instar	6	10	6	7.5
3rd instar	4	5	4	4.7
4th instar	4	6	3	4.0
Adult	4	11	3	5.2
Time from beginning of second instar to spinning cocoon	6	7	4	5.3
Total		54	37	45.7

N. B.—Temperature 68 to 71 degrees Fahr.

Locomotor Activities.—In order to test the speed of locomotion of the various instars, females of the various stages were placed on black paper, ten at a time, on the top of a table, and were allowed to move at will. These tests were carried out between the hours of 2.30 and 3.30 p.m. on clear, sunny days, the duration of each being one hour. The room in which the tests were conducted has the walls painted dead white, and there are three windows situated to the south-east of the table on which the insects were allowed to wander. Table III summarizes the results of the tests.

TABLE III.—Distances travelled by various instars of P. citri in one hour.

ADULTS.—(Temp. 68 degrees F.)

Number	1	2	3	4	5	6	7	8	9	10
Actual dis. travelled	69.5″	29.0″	0.0″	4.5″	31.5″	7.5″	31.5″	54.5″	16.0″	11.5″
From start	41.0″	16.0″	0.0″	1.5″	17.5″	3.0″	12.5″	37.5″	6.5″	8.0″

Averages- Actual—25.5″- From start—14.3″.

3RD INSTAR.—(Temp. 69 degrees F.)

Number	1	2	3	4	5	6	7	8	9	10
Actual dis. travelled	32.5″	34.0″	43.0″	37.5″	63.5″	36.0″	0.0″	47.0″	32.0″	54.5″
From start	19.5″	14.5″	22.5″	27.0″	23.0″	23.5″	0.0″	21.5″	14.0″	26.0″

Averages: Actual—38.0″; From start—19.1″.

2ND INSTAR.—(Temp. 68 degrees F.)

Number	1	2	3	4	5	6	7	8	9	10
Actual dis. travelled	37.5″	21.0″	28.5″	22.5″	27.5″	0.0″	43.5″	23.0″	49.0″	0.0″
From start	20.0″	16.5″	18.0″	7.0″	21.5″	0.0″	21.0″	20.0″	28.5″	0.0″

Averages: Actual—25.2″; From start—15.2″.

1ST INSTAR.—(Temp. 70 degrees F.)

Number	1	2	3	4	5	6	7	8	9	10
Actual dis. travelled	79.5″	83.0″	67.5″	72.5″	59.5″	67.0″	78.5″	86.0″	33.0″	64.5″
From start	48.5″	59.0″	39.5″	47.0″	17.0″	39.5″	46.0″	47.0″	30.5″	37.0″

Averages: Actual—69.1″; From start—41.1″.

From the above it is evident that the tendency to wander exhibited in the various instars decreases, under the conditions cited, in the following order:—first instar, third instar, adult, second instar. The figures in the above table cannot give any precise information as to the relative speed of locomotion in the various instars, owing to the fact that so few individuals were observed; nevertheless they serve to illustrate in an approximate numerical form the

well-marked tendencies of the very young nymphs to wander freely after hatching and of the older stages to exhibit a relatively sedentary habit.

Summary.—The common or citrus mealybug is a greenhouse and citrus crop pest of almost cosmopolitan distribution and has a wide range of hosts. It has been reported to occur in Canada for nearly a century, although the exact date of its introduction is not known.

The details of the life history and of the stages of the insect were studied and a technique for the mounting of specimens for study was developed as a modification of preexisting methods.

The insect appears on a variety of greenhouse plants as a small yellowish, flattened, oval, or convex-ovoid body about ⅛ of an inch long, with a coating of fine white mealy wax, and with thirty-six fine white pencils of wax extending from the periphery. The adult females lay on an average about 200 eggs over a period of some two weeks. The eggs are minute, elongate, yellowish in colour, and laid in an "ovisac" consistng of delicate threads of wax secreted from the wax pores of the posterior end of the body of the female. They are retained in the ovisac until hatching, a period of some 12 days. The newly hatched nymphs are miniature replicas of the adults. They remain in the ovisac for a day or two and then move upward and outward on the plant in search of a feeding place.

After wandering for a few hours the nymphs settle in the axils of leaves or of veins and suck the plant juices, moving from time to time to new feeding grounds. The female nymphs moult three times before attaining maturity, in a period of about five weeks. Female mealybugs retain their appendages throughout life, and are capable of locomotion at any time if disturbed. The total length of life of a female mealybug is about 10 weeks.

Male mealybugs moult four times. Until the time of the first moult they cannot be distinguished from the females except by microscopical examination, but at that time they lose their mouth-parts. Soon after the first moult they seek out a sheltered spot and there spin cocoons of fine, white, wax threads. Within this they complete their development, changing gradually from an oval to an elongate form, and at the same time obtaining a pair of wings and two additional pairs of eyes. The adult males are fusiform, brownish flies, with a covering of finely granular wax. They are about ⅙ inch long and have a single pair of large, oval, smoky coloured, delicate wings. In a few hours they emerge from the cocoon, mate, and die within about five days. Male mealybugs live a total of about 6 weeks.

Tables are given showing the durations of the various stages and the speed of locomotion of the female instars. Two plates illustrate the form of the instars and certain taxonomic characters.

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KEY TO PLATE I

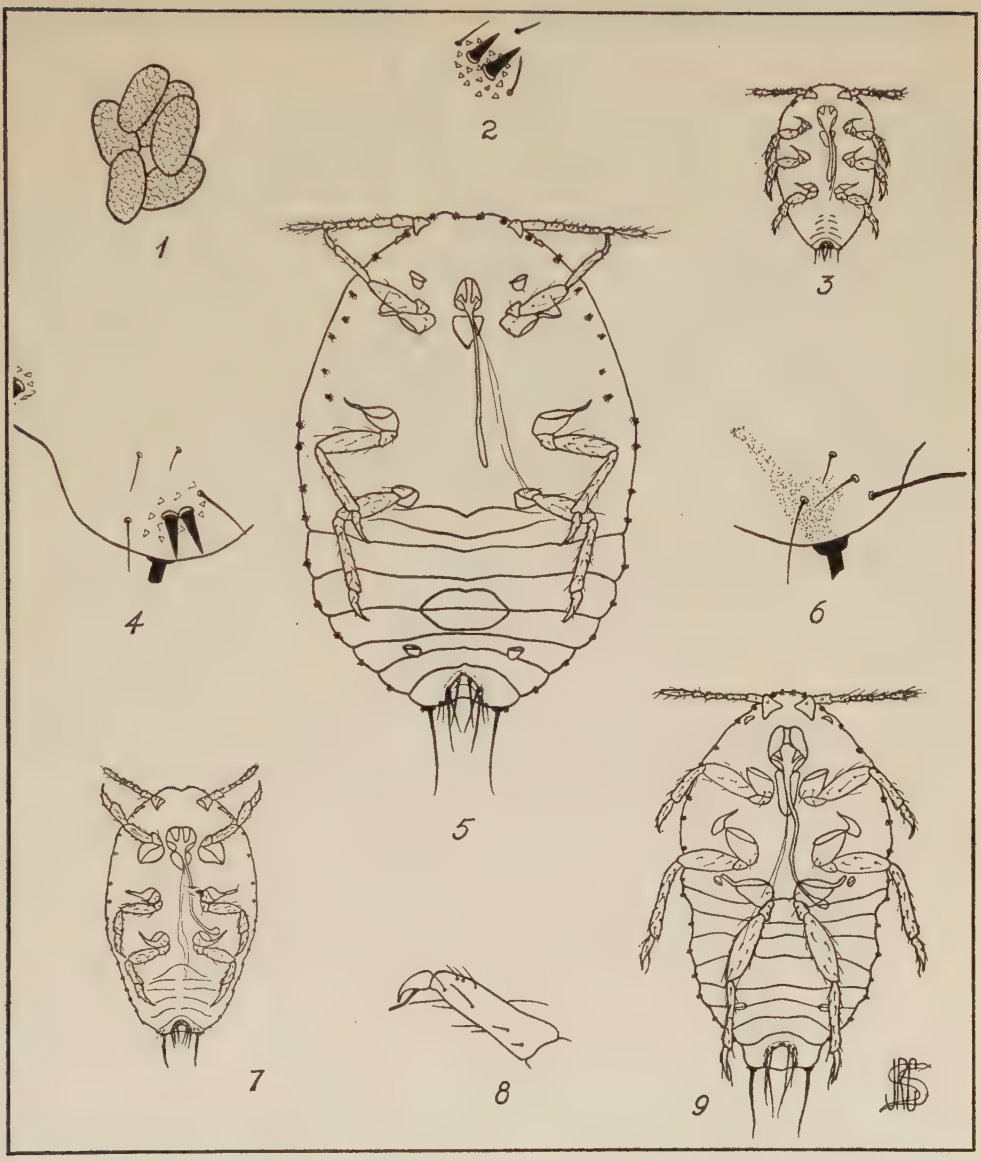
Pseudococcus citri Risso:—

1. Egg, x 20
2. A cerarius, x. ca. 200
3. First instar nymph, ventral view, x 50
4. Anal lobe of adult female, ventral view, x
5. Adult female, ventral view, x 25
6. Anal lobe of adult female, dorsal view, x 200
7. Second instar female nymph, ventral view, x 50
8. Tarsus of adult female, x 100
9. Third instar female nymph, ventral view, x 50

KEY TO PLATE II

Pseudococcus citri Risso:—

1. Adult male, dorsal view, x 50
2. Third instar male nymph, dorsal view, x 50
3. Fourth instar male nymph, dorsal view, x 50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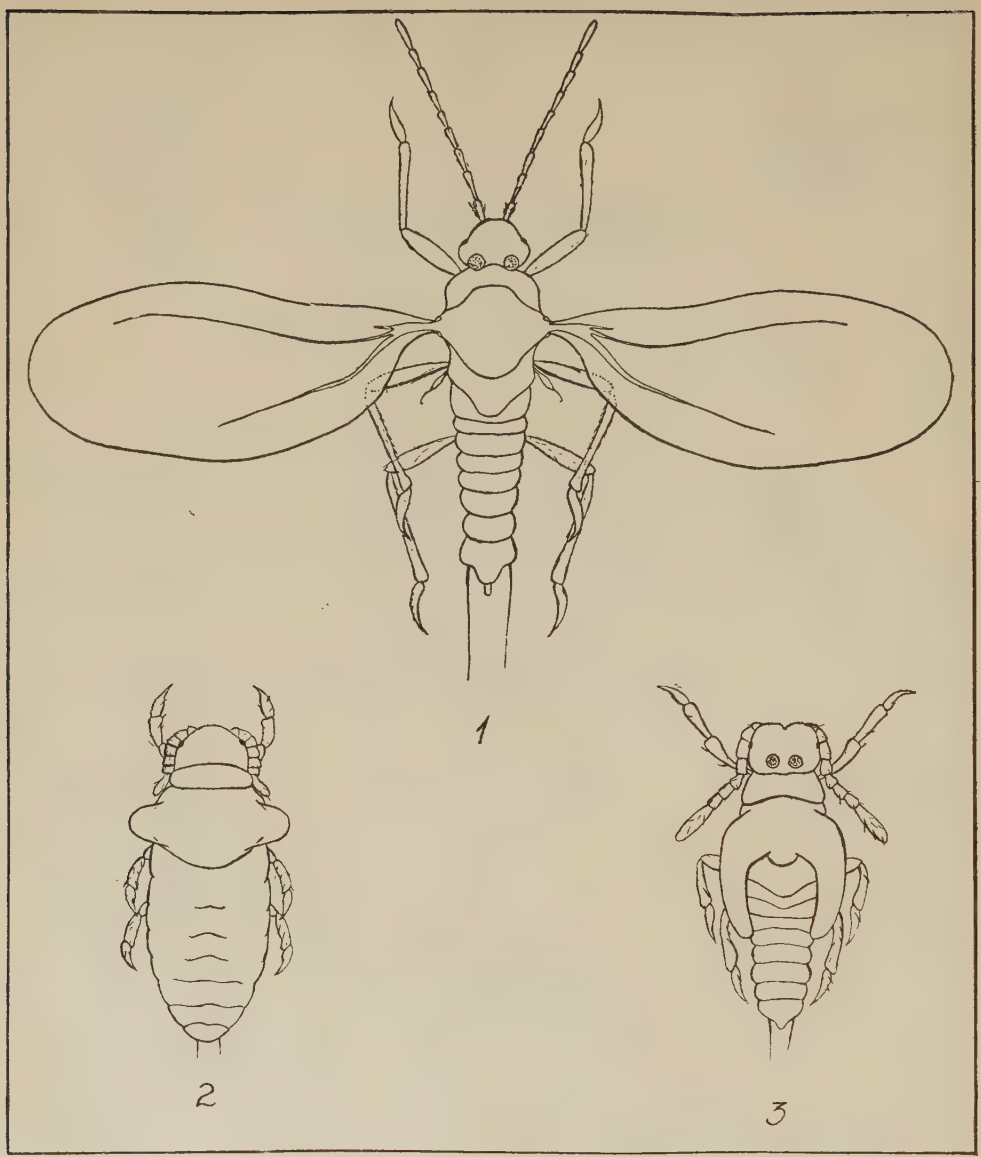
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STUDIES ON A PHYSIOLOGICAL SPOTTING OF APPLES

R. F. Suit

Introduction

The occurrence of a physiological disease always brings forth the question as to the cause. Consequently the presence of a non-parasitic spotting on Fameuse and McIntosh apples in the orchard at the Oka Agricultural Institute during August and September, 1931, was the incentive for further investigations as to the probable reasons for the disease.

In 1915 McAlpine (3) expressed the idea that bitter pit was caused by a concentration of the cell sap followed by consequent death of the cell when the water available was below the requirement. However, in 1921 he (4) changed to the theory that the disease was caused by a rupturing of the cells due to a rapid flow of sap into the fruit. This, he explained, was a result of rapid changes between dry and moist conditions as well as fluctuating temperatures.

On the other hand, Herbert (2) advanced the theory that the cells in the diseased spots were crushed. He explained the theory by saying that there was starch in the dead cells, and that the diseased areas were sunken. The starch in the dead cells indicated that they had been crushed by neighboring cells that contained sugar and consequently had a higher osmotic value which would enable them to absorb a large amount of sap.

More recent results reported by McLarty (5), (6) showed that a probable explanation of the physiological spotting of apples was root injury. He claimed that dry weather injured the roots in the upper foot or two of soil and consequently there was a reduction in the number of absorbing rootlets. The next year would then show the disease since the area of roots absorbing water was reduced; thus reducing the amount of water available to the trees. These results of McLarty's did not explain how the spots on the apple formed, but were more fundamental and showed why the spots formed. It is the purpose of this paper to report other findings with reference to this disease on apples.

Description of the Disease

From a casual observation, the diseased Fameuse apples were about one-third to one-half grown, rather highly colored, and presented a rather warty appearance. The spots were numerous on each fruit and in many cases inclined to be grouped at the calyx end, although some were diseased only on one side or showed only a few spots. A closer examination showed the spots to be sunken and of a slightly darker color than the normal appearance. However, from the external symptoms, the spots were not brown and were smooth depressions. It appeared as though the injury had occurred and then the normal tissue had kept on growing as much as possible. This fact would give the spot a sunken appearance while the normal tissue would be high between each spot to produce

the warty effect. The diseased apples were inclined to fall prematurely, and by October first all had fallen.

The McIntosh apples did not show the disease until about the middle of September. The disease appeared to be somewhat generally distributed, but was not as severe as on the Fameuse variety. The diseased areas in the McIntosh fruits were not depressed to any extent and were a very dark red in color. The fruit was of normal size and in many cases it was necessary to cut the apples before the disease could be found. However, it was generally observed that the extremely red fruits were more apt to be diseased than were the fruits of normal red color.

With regard to the trees, no symptoms were noticeable except in one case. This Fameuse apple tree was on a ridge, and rather small in size. The apples had been badly diseased and all of them had fallen by the middle of August. The foliage of the tree was of a yellowish green color and looked very unhealthy compared to the normal green color of the other trees. The amount of disease on the other trees varied. Some had diseased apples over the whole tree, while others had only one side, or one or two branches diseased. Also occasionally a branch bearing normal apples would be found on trees otherwise diseased. Neither the McIntosh nor Fameuse trees showed any signs of disease with the one exception cited above.

Internal examination of the diseased fruit showed definite brown spots. These spots were situated just beneath the skin, around the core, or were scattered throughout the pulp. The spots beneath the skin always were associated with a depression of the outer surface. In other respects, the fruit appeared normal. The flesh was firm with normal taste exept for the brown spots which were inclined to be rather flat and a trifle bitter. Apparently the disease had no effect on the formation of seeds as every diseased apple examined had two or more normal seeds.

Diseased and normal Fameuse apples were collected on September first while a second collection was made on September 24th, when both diseased and normal McIntosh and Fameuse apples were also obtained.

A study of the Fameuse apples showed several interesting points. The brown diseased spots were tested for starch with I KI solution. In every case, the tests showed that the dead cells in the diseased spots contained an abundance of starch, while the normal apple tissue surrounding the spots showed no starch present. A further study for enzyme content also showed differences. The tests for catalase, oxidase, peroxidase and organic peroxides used, were the usual laboratory technique. Catalase was measured by the amount of oxygen evolved while the oxidase and peroxidase were tested with two per cent benzidene solution, hydrogen peroxide being added to indicate peroxidase.

The results of these tests on normal and diseased Fameuse apples are shown in Table I. These results show a lower acidity; higher catalase, oxidase, and peroxidase content; lower organic peroxide content; and more color on the part of

the diseased apples. This is probably a result of the disease that hastens the ripening processes.

TABLE I.—Results of Tests upon Diseased and Normal Fameuse Apples for Enzyme Content one day after picking.

Condition	pH	Catalase as c.c. of oxygen	Oxidase	Organic Peroxides	Peroxidase	Color
Severely diseased	2.98*	2.1 cc.	+++	+	++	2/3 red
Slightly diseased	3.1	1.7 cc.	+++	++	++	2/3 red
Normal from Oka	2.7	1.1 cc.	+	+++	+	1/3 red
Normal from Macdonald College	2.68	1.4 cc.	+	+++	+	1/4 red

* Each result is an average of the results from testing 10 individual apples.

The diseased and normal apples were put in cold storage in the basement at a temperature of about 40-45°F. The first lot was stored on September third and the second lot on September 25th. From this time until April 12th, 1932, the apples were sorted occasionally to remove the rotting fruits. On April 12th, all apples were removed from storage and examined. The apples showing the disease were as sound and firm as the normal apples while about the same number of each lot had rotted during the storage period. Internal examination of the diseased fruit showed that the spots were the same size as in September and that the brown spots had not, in any way, affected the normal tissue adjacent to them. Plate I shows cross and longitudinal sections of the diseased apples after storage. The iodine test showed starch to be still present in the diseased areas as would be expected since the cells were dead and could not carry on physiological processes.

Histological examination of the diseased spots showed that each spot was completely surrounded by a cork layer. This probably explains why the diseased areas did not affect the neighboring normal tissue during storage. The formation of the cork layer also indicates that the fruit must have been subjected to the proper conditions for the disease while in a rapidly growing stage. If the fruit had been nearly grown it is probable that there would not have been sufficient cellular activity to form the cork layer around the injured areas.

Relation of the Presence of the Disease to the Amount of Twig Growth

Since the apples were so severely diseased, it was possible that other parts of the tree above ground might show some differences in amount of growth.

Consequently, when the second collection of diseased apples was made, a number of trees were measured as to the amount of twig growth produced during the summer of 1931. McIntosh and Fameuse trees in two different orchards at Oka were measured, as well as some of the trees in the Macdonald College orchard. These measurements presented some interesting differences. A summary of the results is given in Table II. These results show that the diseased trees produced less twig growth than normal trees. This indicates a possible lack of vitality on the part of the diseased trees as compared to the normal trees. However, the differences in the amount of twig growth are small and consequently are not as indicative as one would like them to be.

TABLE II.—A Comparison of Average Twig Growth of Diseased and Normal McIntosh and Fameuse Apple Trees.

Variety	Location	Disease	Average length of Twigs
Fameuse	Macdonald College	None	9.2* inches
"	Oka-orchard *1	+++	6.0 "
"	" "	++	7.5 "
"	" "	+	8.6 "
McIntosh	Macdonald College	None	8.2 "
"	Oka-Orchard *1	None	9.0 "
"	" "	++	7.4 "
"	" " *2	++	4.0 "
"	" "	None	5.6 "

* Average of 50 twigs from each of two trees. Measurements taken at random in making one complete round of a tree.

Studies of Roots from Diseased and Normal Apple Trees.

Since McLarty (5), (6) reported that drought spot was probably caused by injury to the root system of the tree, it was decided to examine the roots of the severely diseased trees for any sort of injury. Consequently on September 24th, roots were obtained from certain of the diseased trees at the Oka Agricultural Institute. These roots were taken from the first foot of soil and about eight to ten feet from the trunk of the tree. The roots were kept covered with soil in flats to protect them from drying.

On September 25th, roots were obtained from trees at Macdonald College and as many four-inch cuttings as possible were made from each lot of roots. At the same time, material was obtained for histological study. These cuttings were planted in compost and observed for 50 days. At this time they were dug and examined. Table III shows the results from this experiment. It is easily seen that the roots from the normal trees were more viable. The roots from the

Fameuse trees, either normal or diseased, seemed to be more viable than the same lots from the McIntosh. Possibly then, this is a partial explanation for the diseased fruit and less twig growth.

Histological studies of the diseased and normal roots showed startling results. The vascular rays of both the Fameuse and McIntosh diseased roots were plugged with some sort of material. The sections from the normal roots showed only a very small amount of plugging in a few cases. Plate II shows sections of diseased and normal apple roots. The plugged vascular rays of the diseased roots were brown when observed before staining while no brown material could be seen in the normal root. Here, then, we possibly have the seat of all the trouble. What causes the vascular rays to be plugged? The greatest amount of plugging was found in roots about one-fourth of an inch in diameter and smaller. This plugging of the vascular rays would interfere with transverse passage of sap and consequently the absorbing rootlets would not be able to perform their purpose satisfactorily. It is possible that the rate of recovery of the tree would depend upon the removal of the material from the plugged cells.

TABLE III.—A Comparison of the Viability of Root-cuttings from Diseased and Normal Apple Trees.

Variety	Location	Condition	No. Cuttings	No. Dead	No. with Sprouts	No. with Callus
McIntosh	Oka	Diseased	40	40	0	0
"	"	Normal	68	24	24	20
"	Macdonald	"	58	24	14	20
Fameuse	Oka	Diseased	46	18	8	20
Fameuse	Macdonald	Normal	62	4	40	18

NOTE:—Results after 50 days.

Discussion

Has the disease any relation to bitter pit? McAlpine (3) stated that bitter pit could occur any time after the fruit was half grown. The latest report by Carne (1) in 1929 states that true bitter pit occurs only after the fruit has been picked. Also it is noted that bitter pit shows a brown spotting from external examination. In all probability this disease is not true bitter pit. McLarty identified some of the diseased fruit as probably drought-spot. However, the

illustration given by McLarty (5) shows a cracking of the skin and tissues with a russetting effect as severe drought spotting.

The presence of the disease might be explained from the standpoint of root injury. McLarty (5), (6) states that injury to the absorbing rootlets always occurs the year previous to the appearance of the disease. He also stated that the injured roots were very slow in putting out new absorbing rootlets. This might be explained in the following manner. When the absorbing roots are injured, due to dry soil or adverse conditions, the vascular rays in the smaller roots become plugged with material from the dead roots. This fact then, cuts down the absorbing surface of the tree and also keeps new absorbing roots from forming, since the vascular rays are plugged and very little transverse movement of sap could take place. Then during the growing season, a hot dry spell ensues, as around and following July 1st, 1931. This causes excess transpiration. Therefore a tree with diseased roots will be short of water and there will be competition between the growing fruit and the leaves. The leaves, being able to manufacture sugar, have a higher osmotic value and are able to take water away from the fruit. This keeps up until the cells lowest in osmotic value in the fruit are killed by plasmolysis. As was shown, the dead cells in the spots contained starch so that their osmotic value was probably not high. The cells most affected would be at the end of the vascular bundles and when the high temperature was past, with moisture again available, groups of dead cells would be left at various places in the fruit. The other cells, of course, would go on growing and produce the warty effect on the fruit.

It is possible that the absorbing roots of the trees were injured during the summer of 1930 resulting in the plugging of the vascular rays. Then, during the hot period of July 1st, 1931, and succeeding days, the injured roots were not able to supply sufficient moisture so that the fruit was injured. This injury then was first noticed about the middle of August.

Various methods of control have been recommended. McAlpine (4) recommends light pruning while McLarty (5) recommends a constant water supply. However, in this case, the water cannot be regulated, except that a heavy sod of grass is present in the orchard and might allow more water for the trees if plowed under. Also nitrogen has been applied rather heavily every year. It is possible that the addition of some other nutrient, such as potassium, might prove of value and help in removing the material from the plugged vascular rays.

Summary

A physiological disease of apples occurred on McIntosh and Fameuse apples in the orchards at the Oka Agricultural Institute. The appearance of the disease was distinctive and did not resemble bitter pit to any extent. The diseased areas were scattered throughout the individual fruits. After

225 days storage the diseased apples were still sound. The diseased areas did not spread within the fruit tissues. Histological examination showed each diseased spot to be surrounded by a cork layer.

A study of the physiology of the diseased and normal Fameuse apples showed that the diseased fruits were less acid, more highly colored, and had a higher catalase, oxidase, peroxidase and a lower organic peroxide content than the normal fruits.

Measurement of twig growth of diseased and normal trees showed slightly less growth on the part of the diseased trees.

Root cuttings of the diseased and normal McIntosh and Fameuse trees showed that the roots from normal trees were the more viable, while the Fameuse root cuttings showed more viability than the McIntosh.

Histological examination of diseased and normal roots one-fourth inch and less in diameter showed a plugging of the cells of the vascular rays of the diseased roots.

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PLATE I.—Cross and longitudinal sections of diseased Fameuse apples after 225 days in storage. Approximately natural size.

PLATE II.—Cross Section of diseased apple root one-eighth inch in diameter. Plugging of vascular ray cells clearly evident. X64.

PLATE III.—Cross Section of normal apple root one-eighth inch in diameter. Plugging of vascular ray cells practically absent. X64.

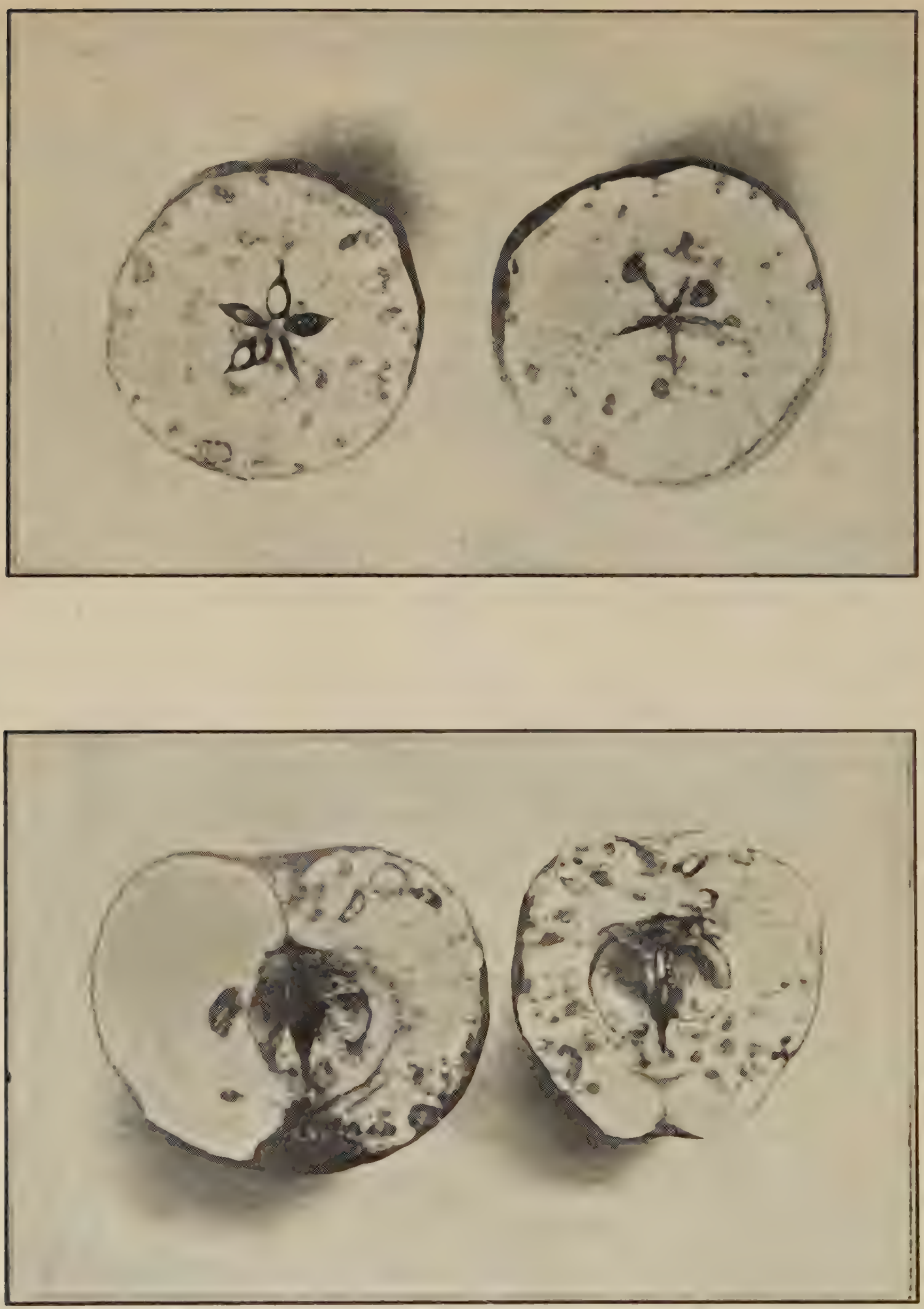

PLATE I.—Cross and longitudinal sections of diseased Fameuse apples after 225 days in storage. Approximately natural size.

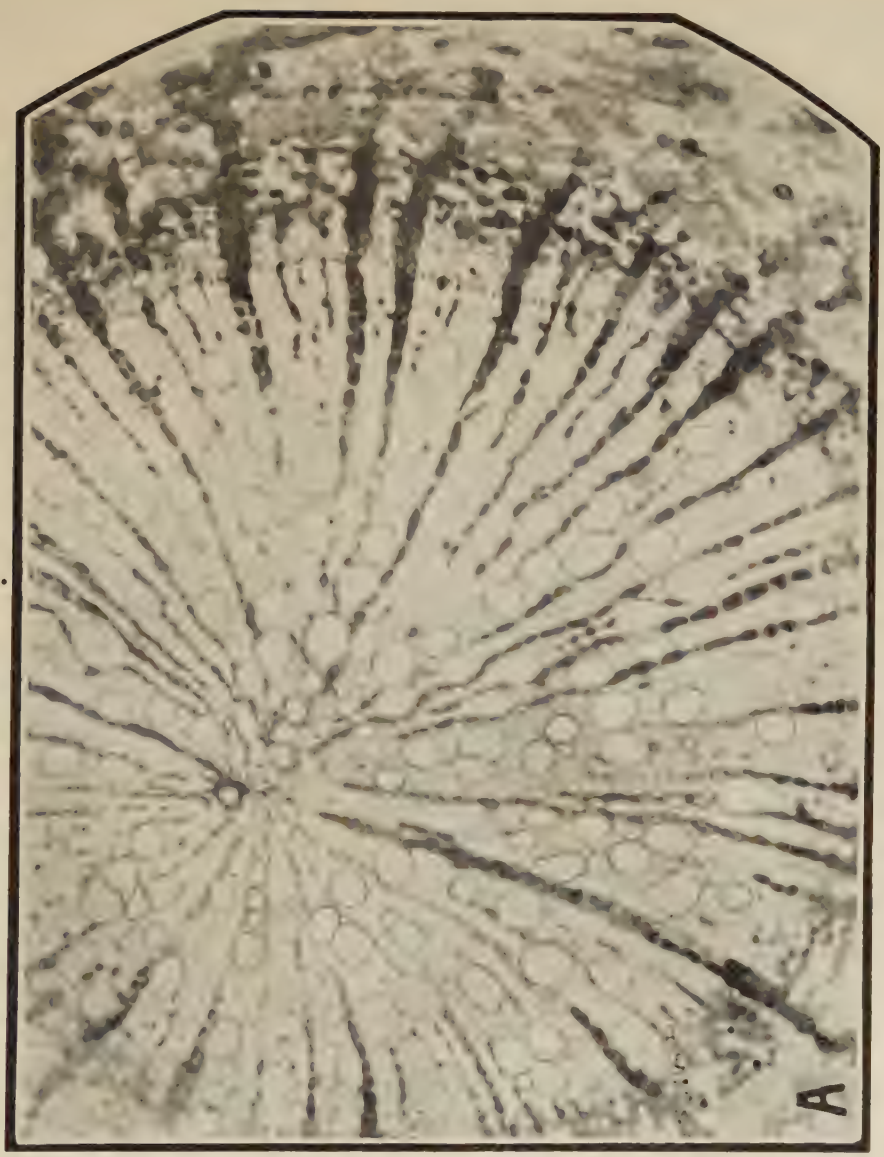

PLATE II.—Cross Section of diseased apple root one-eighth inch in diameter. Plugging of vascular ray cells clearly evident. X64.

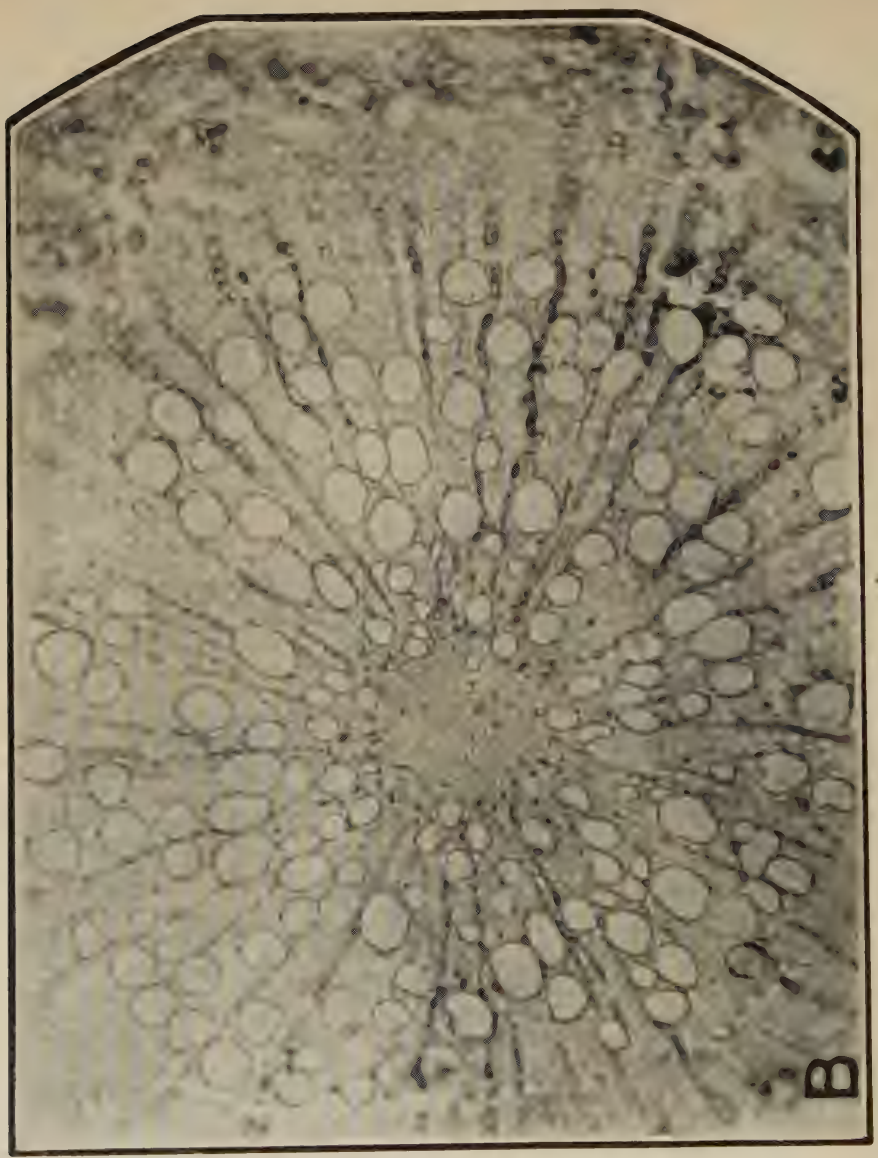

PLATE III.—Cross Section of normal apple root one-eighth inch in diameter. Plugging of vascular ray cells practically absent. X64.

RECENT ADVANCES IN THE KNOWLEDGE OF CROWN GALL OF PLANTS

R. F. Suit

Examination of the Canadian Plant Disease Survey Reports for 1926 to 1931 inclusive shows that crown gall is most prevalent in Ontario. The disease has been reported on apple, peach, pear, blackberry, raspberry and rose. In Quebec, crown gall is known to occur on young apple trees and roses. The extensiveness of the disease on the apple trees is questionable. Thus it is evident that the crown gall disease occurs, but that its presence and destructiveness is not generally known.

The recent work on crown gall can be divided into three groups: first, a study of the identity of the organisms causing malformations other than true crown gall; second, methods for the control of crown gall on nursery apple trees; and third, a study of the secondary galls formed by the crown gall disease. As the results of these three lines of research are being published as separate papers, a brief summary of each will be given as a abstract for the Society's report.

Crown gall and hairyroot are no longer considered as the same disease since *Pseudomonas rhizogenes* R. B. W. K. & S. has been shown to cause hairyroot. Further results on the identity of the crown gall and hairyroot organisms shows them to be distinctly different. The reaction produced on susceptible hosts is characteristic while the bacteriological reactions show *Pseudomonas rhizogenes* to give an acid reaction when grown in certain sugar media while the crown gall organism, *Pseudomonas tumefaciens* Sm. & Town. gives a slightly alkaline reaction. In liquid media *Ps. tumefaciens* forms a pellicle in two to three days while *Ps. rhizogenes* shows clouding only. A further difference is in the production of staling products that, in the case of *Ps. rhozogenes*, kill the organism if left on the same agar slant for six months. The examination of 20 varieties of two and three-year-old apple trees in nurseries in five states showed Wealthy, Yellow Transparent and Duchess as the varieties most susceptible, while a higher percentage of the disease was found in the states of Oklahoma and Kansas than in Iowa and Nebraska. *Ps. rhizogenes* was also found on, and isolated from Floribunda crab, *Spiraea vanhouttii* and *Spiraea prunifolia*. When herbaceous cuttings were inoculated with *Ps. rhizogenes* rooting was stimulated in 30 days on cuttings of Bryophyllum and Paris daisy. Similar inoculations on hardwood cuttings showed a stimulation of rooting of cuttings of apple seedlings, Wealthy apple and *Spiraea vanhouttii*. *Ps. rhizogenes*, usually induces hairyroot on a host in thirty days. The shortest time found was 14 days on young sugar beets, while Wealthy apple required the 30-day period.

The common practice of the use of the tongue or whip graft wrapped with waxed thread in nursery practice of raising apple trees results in a high percentage of trees with root knot. Examination of over 55,000 two and three-year-old apple trees in 1926 showed about 45% unsalable. Proper fitting and care in making were recommended and in 1928 examination of 35,000 trees showed about 35% with root knot. Further attempts at control of root knot involved the use of the wedge or cleft graft. In 1929, the results from 25,000 apple trees showed 20-25% root knot. The next year a light grade of adhesive tape as recommended by the workers at the University of Wisconsin, was used on the wedge graft. The result in 1930 showed only 5-15% root knot on 12 different varieties of apple when 32,000 trees were examined. From the results obtained over a period of three years the use of the wedge or cleft graft wrapped with a light grade of adhesive tape appears to give the most promising results for the control of the excess callus formation on piece-root grafted apple trees.

The formation of secondary tumors on three-year-old apple trees about ten inches above the point of inoculation could not be explained by the theory of intrusive tumor growth or by the theory of elongation of the tissues after inoculation. Consequently it was thought that the organism might travel through the vascular system, should it happen to get into these tissues. Preliminary experiments with tomato plants showed that the organism would travel considerable distances through the vascular system and form secondary galls. Further experiments have verified the preliminary results on tomato and showed that the organism will also travel varying distances through the vascular system of tobacco, Bryophyllum and Paris daisy. Isolations at week intervals have shown that the crown gall organism is still viable within normal tomato stem after 10 weeks from the time of inoculation. The introduction of a broth culture of *Ps. tumefaciens* into the middle of a plant through a petiole, results in the upward movement of the organism when it enters into the main stem. This indicates that the transpiration stream influences the migration of the organism within vascular host tissue. The ringing of Bryophyllum cuttings to remove the phloem showed that the organism travelled through the xylem since the crown-gall organism could be isolated from the tissue above the ring The wounding of inoculated cuttings on the internode resulted in the production of secondary galls at the point of wounding in about 35 per cent of the cases.

THE CARPENTER WORM, (PRIONOXYSTUS ROBINIAE) PECK, AND ITS CONTROL

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Introduction

The injury to valuable shade trees caused by the carpenter worm, *Prionoxystus robiniae* Peck, suggested special studies on the life-history and the control of this insect. During the summer of 1928, a light infestation of carpenter worms was found at Ste. Anne de Bellevue, Que., and several shade trees were suffering from the injury.

With the intention of adding further information to the literature relating to this pest, it was decided to carry on investigations on its bionomics and control.

The following study is the result of observations made during 1929 and 1930, supplemented with previous knowledge about this important problem. The work has been divided into two main sections. In the first section, economic importance, food plants, habits and life-history of the insect are dealt with, while the second section deals with the artificial control by the use of calcium cyanide in mixture with raw linseed oil.

Economic Importance and Distribution

Among our most injurious wood-boring insects, the carpenter worm holds a rather important place. The injury this insect may cause to some species of shade trees, like maple and oak for instance, makes it necessary for the investigator to attach much importance to the matter. The infestations found at Ste. Anne de Bellevue, and St. Laurent, Que., revealed the necessity of fighting this pest in opportune time, otherwise, a large number of valuable shade trees would be ruined as a consequence of successive infestations. It was found that about 30% of the soft or silver maple, *Acer saccharinum* Linné, were infested and that several other specimens had died or were considered too seriously injured to live much longer. A single shade tree destroyed by this insect may represent a considerable loss, because large sums of money are spent every year for the preservation of ornamental and shade trees.

The carpenter worm is widely distributed throughout the United States and Eastern Canada. There are several localities situated on the Island of Montreal in which this pest was found to be very injurious to maples bordering on highways, avenues and private lanes. *Prionoxystus robiniae* Peck was quite active during 1929 in the following localities located on the Island of Montreal, viz., Ste. Anne de Bellevue, Senneville, Cartierville, St. Laurent, Dorval and Beaurepaire. Several specimens of this pest were also found at Abbotsford, Hemmingford, Sorel district and several other localities on the north side of the St. Lawrence river between Montreal and Three Rivers.

Habits

During the month of June, 1929, a large number of silver maples were inspected near houses, in open fields, and maple groves in mostly all the localities situated on the Island of Montreal. From this inspection, it was found that only aged trees located in the neighbourhood of houses or open fields, were infested with carpenter worms; whereas extensive maple groves and thick woods were not infested, except at the extreme edge and where such woods were situated close to an old infestation. These conditions were especially observed on Macdonald College farm where a high percentage of the trees growing along lanes, which were in the open, were heavily infested; whereas the maple bush, situated at a distance of a few acres, did not show any traces of the insect except on a few trees growing at the outer edge facing the infested area.

A similar condition may be observed around the mountain in Montreal. In this case, no infested trees could be found among the closely growing trees on the mountain, although the nearest infestation was located within a few miles. Before drawing any definite conclusions from the above mentioned observations, further studies should be made. However, they indicate that the ovipositing of the female carpenter moth is confined to open areas. The eggs are deposited preferably on old and sickly trees. Upon hatching, the young larvae bore their way through the bark and begin to feed on the cambium. They gradually increase in size and strength until their mandibles are powerful enough to bore tunnels through the heartwood.

After the loose bark has been removed from the infested area and the wound well cleaned, the presence of the borers is indicated by the ejection of fresh castings. In many instances, some of the castings were mixed with silk produced by the larvae to form a passage-way for the borers, extending from the aperture of the tunnels to the sappy edge of the cambium. Some of these covered passages were as much as four inches in length. So far as observed, these passages allowed the worms to feed on the cambium and sapwood during the night by offering a protection against enemies, but before the loose bark is removed from the tree, the larvae feed without the help of a protective or leading passage. Under natural conditions, passages are made under the loose bark and among castings.

Life-History

Egg-laying occurs shortly after the moths have emerged from their hosts. In 1929, egg-laying was first recorded on June 26, and July 6, a female moth was observed resting on the trunk of a tree where it had oviposited. The eggs were deposited irregularly in crevices of the bark and around the edge of scars and wounds. Upon hatching, the young larvae bore their way through the bark and begin to feed on the cambium. They remain there until the second year, and during this period there are no signs of tunnel making. About July

of the second year, these worms have attained enough strength to start feeding in the sapwood and somewhat deeper. By June of the third year, they have entered the heart wood where they develop and change to pupae, which stage is reached in May of the fourth year. Finally they become adults and emerge from their tunnels.

According to observations made in 1929, all stages of larvae caused injury to infested trees. It is the feeding done in the cambium that causes most damage and this condition lasts through the entire larval period.

On emerging, the moths leave their pupal cases at the aperture of the tunnels and these may be collected in June. The carpenter moth has nocturnal habits and possesses only vestigial mouth parts which prevent it from feeding. Certain investigators have reported that a single female moth is capable of laying as many as 200 to 300 eggs.

Control

In conjunction with the studies on the life-history of the carpenter worm, a few control experiments were also carried out. A test made in 1928 with a thick mixture of Cyanogas dust and castor oil against *P. robiniae* Peck, suggested further investigations along this line. The results obtained in 1929 and 1930 were quite satisfactory. The methods used at different periods were very simple and of great value on large shade trees.

The control experiments were carried on at Ste. Anne de Bellevue and St. Laurent, Que. The trees under experimentation were heavily infested and considerable injury had already been done as a result of successive infestations.

After the loose bark had been removed with a small axe and the wound well cleaned of old castings and other waste, the trees were left in that state for a period of several days. At the end of this period, more castings were readily observed and this condition made it possible to locate the tunnels in which the larvae were actually feeding. With this information at hand, these tunnels were treated with a calcium cyanide-oil mixture mostly by means of a grease gun and a small paint brush ¾ inch in diameter. The mixture is forced into the tunnels with a grease gun and any amount that is exuded is brushed back by the paint brush.

The best results were obtained with either Calcyanide grade No. 1 or Cyanogas grade "A" in raw linseed oil. The mixture should be thick enough to drop but not run off the paint brush. The total treatments with the above materials gave an average control of 92 per cent and several experiments gave as mush as 100 per cent control. On the average, the results obtained were rather encouraging for the practical and economical control of the carpenter worm. The trees should be inspected periodically for reinfestations and treated accordingly.

Figure 1.—General appearance of maple tree injured by carpenter worm with dead bark removed.

Figure 2.—Detailed appearance of injury due to carpenter worm.

Figure 3.—Tunnels due to carpenter worm larvae feeding in heartwood.

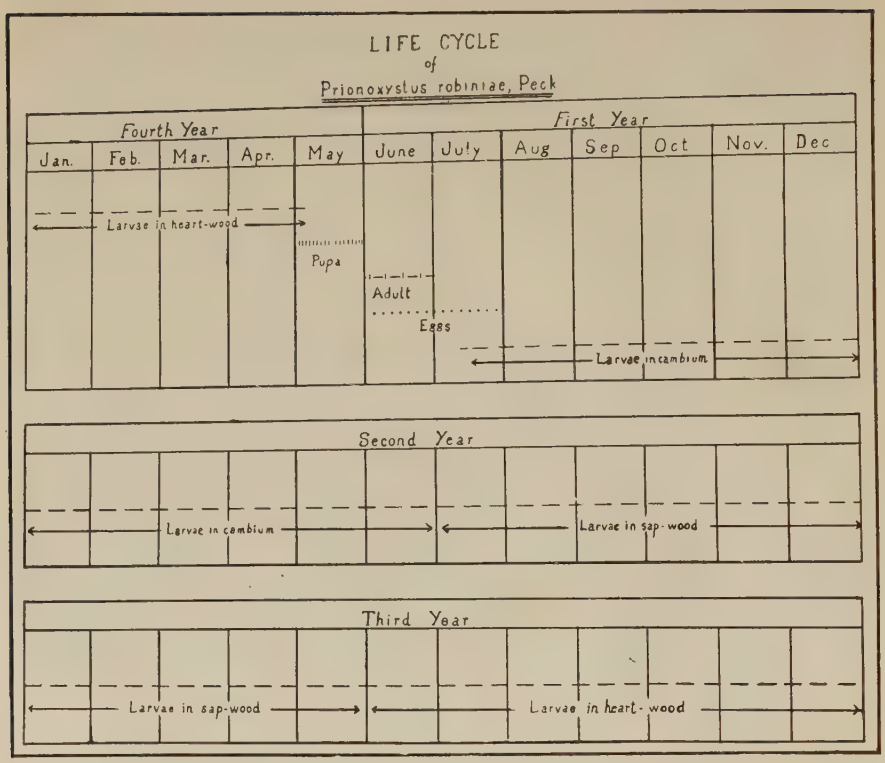

Figure 4.—Life Cycle of Prionoxystus robiniae, Peck.

MOSQUITO INVESTIGATIONS IN CANADA DURING 1931

By Arthur Gibson, Dominion Entomologist, Department of Agriculture, Ottawa.

Mosquito investigations in Canada have continued to occupy our attention to an important degree during 1931, and we feel that progress has been made.

Investigations in British Columbia.

Harrison Lake, B. C.—In 1926-27 and 1927-28, a survey of the mosquito breeding areas adjacent to the Harrison Hot Springs Hotel was completed by Mr. R. Glendenning, Dominion Entomological Laboratory, Agassiz, B. C. In this immediate district, *Aedes aldrichi* D. & K., *A. vexans* Mgn. and *A. cinereus* Mgn. had previously been very abundant and annoying. The control work conducted in 1931 was similar to that of 1930. The breeding areas were treated with diesel oil, practically 100 per cent of the larvae being killed.

Chilliwack, B. C.—During 1931, under the direction of Mr. R. Glendenning of our federal entomological service, a survey of the district was continued. In reporting upon this work, Mr. Glendenning says: "Mr. Cianci, assistant at the Agassiz laboratory, spent part of April, May, June and July in the Chilliwack district locating and mapping the breeding areas. Control work was performed for the first time this year (1931), 1200 gallons of diesel oil being applied to the breeding swamps. The Fraser river, the cause of the flooding, did not rise to average flood height, being about three feet lower at the maximum, so no very large areas were flooded. The survey is still incomplete owing to the fact that no mapping has been done when the water is up to average height.

The total area under survey is about 50 square miles. $569.00 were spent this year, the money being raised by public subscription with small grants from local city and municipal bodies.

About two miles of trails through dense brush were cut, and 600 acres of swamp oiled."

Point Grey, Vancouver, B. C.—At the request of the Point Grey Golf and Country Club, Mr. Glendenning in 1931, located important breeding areas adjacent to the course. He reports: "The breeding swamps were eventually located in a peaty swamp on Iona Island in the mouth of the Fraser river about one mile from the course. *Aedes dorsalis* Mgn., the species causing the trouble on the course, was found breeding in immense numbers. The survey revealed the fact that the swamp could be drained by ditches from 2 to 3 feet deep opening to the river. The tidal lands adjacent were not found to be regular

breeding places of this or any other species. At one time larvae of *Aedes vexans* Mgn., were found abundantly in one area."

Kamloops, B. C.—Mosquito control work in the district of Kamloops was again supervised by Mr. E. Hearle, resident federal entomologist. While in western Canada in August, 1931, I had an opportunity of going over this work with Mr. Hearle. The latter has since reported:

"Excellent results were obtained, in spite of rather more difficult conditions than have occurred since the commencement of this project. While the Thompson river did not reach an unusually high level (13.7, June 20) and, in fact, the freshet was a foot below the average for an eighteen year period, three distinct peaks occurred and the period of flood was much prolonged, the river being over the flood level (10.0 feet) for more than a month (June). Another adverse factor was the very heavy rainfall that occurred for nearly a week in late June—a most exceptional condition in this "dry belt" area.

Oiling operations commenced on May 18, when the first slight flooding of egg beds occurred, and the control work was completed by July 24. The total expenditure this year was slightly under $900.00, included in this being an outboard motor which was added to the permanent equipment and which proved of great value in speeding up some of the work, facilitating inspections and so forth.

Control work was again somewhat hampered by Indians refusing to permit oiling of the extensive flooded meadows situated on the Kamloops Indian Reserve, and a deadlock was prevented only through the co-operation of the federal Indian Department. Fortunately, the Indians harvested an excellent crop of hay this year, thanks to the prolonged flooding. Since the meadows were thoroughly oiled, it is hoped that they will be convinced that their fears of oil damage were unfounded.

While absolute freedom from mosquitoes was not attained, good control resulted from the work carried out and no noticeable mosquito trouble was evident, except for one day (July 8) when a migration from some unknown source infested the town. Collections at a number of points throughout the town on the previous day gave only a very few mosquitoes (mainly *Aedes vexans* Mgn.). Systematic collections were made throughout the district during the mosquito season and these gave very definite evidence of the success of control operations. In places outside the area embraced by the control project mosquitoes were very troublesome and were considerably worse than usual, in fact certain Boy Scout camps were closed down for this reason.

One point of interest was brought out as a result of the large number of collections of adult and larval mosquitoes made in the Kamloops district, *i. e.* the preponderance of *Aedes vexans* Mgn., over *Aedes aldrichi* D. & K., which is the dominant species in seasons of high flood. Egg beds of the former in low open meadows are flooded at a lower river level than the egg beds of *aldrichi* in wooded bottom lands, many of which are at a slightly higher elevation.

In addition to control work, much investigation was undertaken of breeding places in the district, and various additions were made to maps showing the location of these. Extensive collections of early stages have added some information on the mosquitoes of the district.

The following is a list of the twenty mosquito species so far noted:—

Dominant species of major importance

Aedes aldrichi Dyar and Knab	Very abundant
Aedes vexans Meigen	" "

Species of lesser importance, but fairly common at times

Aedes campestris Dyar and Knab	Common in springs following
Aedes cataphylla Dyar	much winter snowfall
Aedes dorsalis Meigen	Fairly common
Aedes fitchii Felt and Young	" "
Aedes stimulans Walker	" "
Aedes excrucians Walker	" "
Aedes idahoensis Theobald	" "
Culex tarsalis Coquillett	" "

Species of minor importance, usually scarce

Anopheles maculipennis Meigen	Scarce
Theobaldia inornatus Williston	Moderately common
Theobaldia incidens Thompson	" "
Theobaldia impatiens Walker	Very scarce
Aedes punctor Kirby	Fairly scarce
Aedes cinereus Meigen	" "
Aedes canadensis Theobald	Scarce
Aedes hirsuteron Theobald	"
Aedes communis de Geer	Very scarce
Aedes impiger Walker	" "

Irrigation is an essential agricultural practice in the district and during the last few years fairly large acreages of "sage brush" land have been broken up and brought under cultivation for the production of truck crops, such as tomatoes, potatoes, etc. It was thought that this might result in an increase in the numbers of some of the above species such as *Culex tarsalis* Coq., *Anopheles maculipennis* Mgn., etc., which sometimes develop in great numbers in seepage filled ditches and semipermanent pools, in depressions, etc. So far this has not occurred to any extent, since the soil is light and water does not usually stand long. Production of *Aedes campestris* D. & K. has, however, been noted in a few irrigation drainage pools, but not sufficiently so to cause any appreciable mos-

quito trouble. Except when unusually heavy winter snowfall results in the production of *Aedes campestris* D. & K. and *Aedes cataphylla* Dyar in very early spring snow pools, the Kamloops mosquito pest is almost entirely a flood pool problem."

Tranquille, B. C.—This problem is essentially similar to that of Kamloops, but is on a somewhat larger scale. Control work undertaken by the Tranquille Sanatarium authorities was supervised by Mr. Hearle of the Dominion Entomological Laboratory at Kamloops, and investigations were carried out in connection with the main breeding areas. The results of control operations were very satisfactory.

Salt Springs Island, B. C.—Mr. W. Downes, of our Victoria Entomological laboratory, undertook brief investigations of a serious mosquito pest occurring in the northern section of Salt Springs Island. In this island, and in most parts of the main Vancouver Island, mosquitoes are comparatively scarce. Here and there, however, in the salt marshes there are considerable numbers of *Aedes dorsalis* Mgn. On August 28 and 29, Messrs. Downes and Hearle investigated the northern area of Salt Springs Island. *Aedes dorsalis* Mgn. was found to be the dominant species and a large swampy area known as Stone-cutters lake was the most important breeding area noted. *Aedes fitchii* F. & Y. was another species noted earlier in the season.

Kelowna, B. C.—According to information received from the Secretary of Kelowna District Mosquito Control Association, the spring survey of the sloughs within the city boundaries indicated that the insects were appearing very early. Prompt treatment of the infested areas destroyed an enormous number of wrigglers. Mr. Craig, the Secretary of the Association, reported that the control work was continued throughout the season, applications of oil being made when necessary. A committee of ladies raised $324 by means of a raffle, which indicates the interest taken by the town people in controlling mosquitoes.

Investigations in Alberta

Banff, Alta.—Regarding work at Banff, Mr. C. G. Childs, Resident Engineer, Rocky Mountains National Park, reports as follows:—Mosquito control operations in 1931 were very successful. While the lack of winter snowfall last year no doubt aided our work considerably one new factor has arisen which greatly increased the difficulties. This is the extraordinary increase in the number of beaver colonies in the vicinity of Banff. These animals construct dams in the drainage ditches and are so persistent that they will entirely rebuild a dam in a night after it has been destroyed during the day.

The activities of the beaver have flooded large areas that in former seasons have been dry.

Larvae were first noted at the beginning of April, but the weather remained cold until April 15. Operations were started in the Recreation Ground area on April 20, and continued until August 14. A total of 3000 gallons of Imperial Oil #105 was used during the season. D. Gillies, as in the past five years, was foreman in charge of the work.

While not engaged in oiling, the gang, consisting of four men, were employed in extending the drainage ditches and cutting new trails through the swamps. Each year this work opens up new breeding areas and is an important part of our control operations.

An experiment was tried this year in the use of saw dust impregnated with oil on the larger water areas. Sacks of sawdust, which had previously been soaked in oil, were placed at the upper end of these pools. After a few hours a satisfactory film of oil had spread over the surface. This resulted in considerable saving of time and expense.

The cost of mosquito control operations this year exceeded our appropriation by nearly $400.00. It amounted to, in labour $1,930.64, and in material, (oil, boots, spraymotor, etc.) $656.78, totalling $2,587.42.

Jasper, Alta.—In the spring of 1931, officials of the Canadian National Railways requested me to arrange for an investigation of the mosquito pest, stated to be sometimes troublesome in the vicinity of Jasper Park Lodge, a beautifully-placed tourist resort in one of Canada's most attractive mountain "play-grounds". Mr. Eric Hearle, of our entomological service, was detailed to undertake this investigation, but unfortunately, owing to other projects in progress, a brief preliminary survey of the situation was all that was possible. Mr. Hearle has reported as follows:—

"Collections of adult and larval mosquitoes and examinations of various types of breeding places in the course of short trips made during May, June and July, resulted in the accumulation of much data which will be of value in connection with a more adequate and extended investigation which it is hoped to conduct during 1932. *Aedes intrudens* Dyar was by far the most abundant species noted and *Aedes hirsuteron* Theo., *Aedes communis* de Geer, *Aedes dorsalis* Mgn., and *Aedes canadensis* Theo., were other species observed that may prove to be of importance. Snowfall in the winter of 1930-31 was rather light and the impression was obtained during the first visit in May that mosquitoes were hardly likely to be a serious pest in this district and that other biting flies, possibly black flies, had been mistaken for them.

The Miette river flooded extensive heavily wooded bottom lands in late June and this was the only area in the district where great production of mosquitoes was noted. During investigations from July 8 to 17, it was evident that little dispersion occurred, since mosquitoes were seldom very troublesome more

than one-half mile away from the Miette river flood lands. The weather during this time was very wet. In the low-lying woods immediately adjacent to the Miette river the mosquito population was extremely dense, *Aedes intrudens* Dyar being the main species noted. *Aedes hirsuteron* Theo., *pionips* Dyar, *cataphylla* Dyar, *communis* de Geer, *fitchii* F. & Y. and *cinereus* Mgn., also occurred in some numbers. During these ten days, mosquitoes had remained so scarce in the vicinity of Jasper Park Lodge (about 1½ miles distant) that it seemed improbable that any serious mosquito trouble would be experienced."

Mr. Hearle left Jasper for other work on July 17, and on July 24 the town of Jasper and Jasper Park Lodge suffered from an extremely bad infestation of mosquitoes—in fact, the pest was worse than anything that had occurred in this locality for many years. The pest lasted less than a week and ceased as suddenly as it had commenced. In company with Mr. Hearle I made an inspection of the Jasper project on July 31. It is planned to continue this work in 1932.

Investigations in Saskatchewan

Prince Albert, Sask.—Accompanied by Mr. K. M. King, I visited the Prince Albert National Park, Sask., on July 29. Previously during the year, Mr. King, with one of his associates, spent a few days at the main camp cite in the park, namely May 30 to June 2. His report reads:

"This visit came at a very opportune time since the first swarm of mosquitoes had begun to appear a day or two previously and many large wrigglers and pupae were found in the camp area. Some hundreds of wrigglers were secured in seven collections and about seventy adults in five collections at different places. Acting on our recommendations, oiling was done at a few places in the draining ditches in which breeding was occurring and apparently had complete success.

Some 45 adults were secured at various times later in the season, through the courtesy of collaborators, chiefly Mr. Jacob Rempel of the University of Saskatchewan.

From the various determinations made by Mr. Hearle on this and other material, it is evident that *Aedes intrudens* Dyar is by far the chief species of importance in the camp and is evidently breeding in the immediate locality of the camp.

The season at the park should have been very favourable, on the whole, for mosquito breeding. There was a heavy snow deposit which thawed very rapidly resulting in very widespread flooding, the undrained pools persisting for a considerable period. The spring itself was fairly dry but the subsequent season was wet, there being frequent rains throughout June and July. These facts serve to emphasize the very high degree of effectiveness of the control

measures which have been instituted at the main camp. Throughout the season very little trouble with mosquitoes was experienced at this camp. The pest was moderately troublesome for a few days beginning about May 29 or 30 but soon dropped off; and on July 26, for example, one of our men could find no mosquitoes whatever in a considerable search through the camp, although at the same period they were abundant around sloughs some distance from the camp."

Saskatoon, Sask.—The notes on the mosquito work at Saskatoon, forwarded to me by Mr. King, have been secured through the kindness of Dr. L. G. Saunders of the University of Saskatchewan, who in 1931, as in previous years, has acted in an advisory capacity. As before, the work has been undertaken under the direction of the Young Men's Section of the Board of Trade, Mr. L'Ami having general supervision. This year $450.00 was spent for labour, in addition to a capital expenditure of $150.00 on a truck. There appears to have been no expense for materials, old cylinder oil having been used entirely. Work continued throughout the season until July 15 when it was necessary to terminate it owing to lack of further funds.

Mosquitoes were noticeably scarce throughout the season in Saskatoon (including the golf course). Towards the end of the season a few were noticed around the University gardens. The season here was generally unfavourable for mosquito breeding although a heavy rain which fell on the last day of June was sufficient to fill many pools and probably a considerable pest might have developed had it not been for the oiling operations.

Investigations in Manitoba

Winnipeg, Man.—Mosquito suppression work at this centre was again conducted by the general committee of the Winnipeg Anti-Mosquito Campaign, with Dr. H. M. Speechly as Chairman, and John P. Tully as Field Manager. The latter has forwarded the following statement:—

"This season (1931) has been the driest we have ever encountered. With the funds so low it was a great relief to see the spring advance without giving rise to general breeding conditions and so we have completed our control work this year with an expenditure of $5,000.00.

Starting later than usual in May, we sent four gangs of men into the field, who in four days covered all that was left of the early snow and flood waters. At the end of this oiling we re-inspected the whole control area. No further development of wrigglers took place till late May, when the headquarters staff oiled once again whatever water was found."

Dr. Speechly in writing about the campaign says:—

"This campaign was the third in succession which has prevented the mosquito from becoming a pest to Greater Winnipeg. Fortunately from this

point of view it proved to be the easiest year of all on account of the scanty snowfall and rainfall.

This year we had the public on our side; but through an unfortunate postponement of Tag Day from April 11 to April 25, for which the Executive Committee was in no way responsible, the receipts were probably $1,500.00 or $2,000.00 less than they would have been. Tag Day was splendidly staged by the Young Men's Section of the Board of Trade, but the Section will agree very emphatically that only the wonderful pluck and staying power of our lady collectors could have produced such a fine sum as $3,500.00."

Investigations in Ontario

Orillia, Ont.—Reporting on the mosquito work at Orillia under date of July 24, 1931, Mr. Frank Gover stated as follows:—

"The early part of the season was extremely dry and we were able to have a good clean-up. This year, 1931, has been far away the most successful of any. We are getting compliments from all sides."

A little later on, specimens of mosquitoes were received at the Entomological Branch and these were determined by Mr. Twinn as belonging to the species *Aedes vexans* Mgn.

Camp Borden, Ont.—From a report received from Major J. A. Linton, camp medical officer, the camp in 1931 "was singularly free of mosquitoes, whereas surrounding districts showed a larger number than usual." The important mosquito breeding places were oiled as in previous years.

Toronto, Ont.—No serious outbreaks of mosquitoes were reported from the Toronto district in 1931. At Island Park it was considered desirable to oil certain waters and similar action was taken in the vicinity of the Humber river and also in the High Park and Woodbine districts.

Hamilton, Ont.—According to a report received from Mr. C. S. Shain, Health Department, Hamilton, a mixture of pyrethrum powder and light furnace oil in proportion of one pound of the former to one gallon of the latter was used. To this was added one half gallon of water in which 4 ounces of soap had been dissolved. The emulsion thus obtained was used at the rate of one gallon of the mixture to twenty gallons of water. This mixture is similar to that recommended by Dr. J. M. Ginsburg, New Jersey Experiment Station, in 1930. At Hamilton the area treated was approximately 13,049 square yards consisting of marshy land and some underbrush.

Algonquin Park, Ont.—On request of the Superintendent of the Algonquin Provincial Park, I arranged for Mr. C. R. Twinn of our entomological service

to visit the Park, and this he did June 29 to July 4. Reporting on his observations Mr. Twinn says:

"Owing to the late date of my visit and the dryness of the season, it was not possible to find larvae or pupae of the common and troublesome woodland species of mosquitoes developing. Adult specimens, however, were captured and showed, as expected, that *Aedes* mosquitoes which breed in temporary pools, are chiefly responsible for mosquito trouble in the vicinity of Cache lake. Survey trips into the woods surrounding the Park Headquarters, and about various cottages and camps on islands and along the lake shore, revealed many low-lying areas and depressions in the forest floor, which although dry or merely soft and damp at the time of examination, would doubtless be converted into temporary water bodies earlier in the season, and serve as breeding places of mosquitoes.

As the period of maximum mosquito abundance was over, at the time of my visit, these insects were not found to be particularly troublesome. Numbers of specimens of the genus *Aedes*, collected in the evenings were mostly abraded, and showed lateral abdominal patches indicative of advanced ovarian development, proving that they had emerged some time ago. Three species of *Aedes* were taken; namely, *Aedes intrudens* Dyar, *Aedes impiger* Wlk., and *Aedes triseriatus* Say. Of these, *Aedes intrudens* Dyar was the most abundant. There are, undoubtedly, other species of woodland *Aedes* common to this district, but collections would have to be made earlier in the year to establish their presence and identity.

In various places along the shore line of Cache lake, there are areas of drowned timber land where permanent swamps occur. In these swamps, dead tree trunks and stumps stick up from the water and bog laurel and flags (in flower) are the most conspicuous plants. Cat-tails, burr-reeds, horsetails, pond lilies, bladderworts, spagnum and other aquatic plants, typical of permanent swamps, are also common in the water. Careful examination of several of these swamps failed to show the presence of mosquito larvae. Although, in all probability these swamps may give rise to moderate numbers of *Anopheles* and *Mansonia* during the summer, it is highly improbable that they play any significant part in the production of *Aedes*, which are rarely found in permanent water bodies. These swamps, too, are connected directly with the lake, and thus contain large numbers of minnows and other small fish which would serve to prevent mosquito development. In addition, predacious insect and plant life is plentiful, including water boatmen, damsel and dragon fly nymphs, and the bladderworts, *Utricularia macrorhiza* Lec., and *U. minor L.*

That some breeding does occur in the swamps, despite the fact that no larvae could be found, was proven as follows. One evening, after night fall (9.30 p. m.), under two arc lights on the diving pier, close to the Park Headquarters, where a group of people were standing, *Anopheles* mosquitoes became quite annoying. Specimens captured belonged to two species, *Anopheles maculi-*

pennis Mgn., and *A. walkeri* Theo., the latter being the more abundant. Judging from our knowledge of these species, they probably originated from an adjacent swamp, but as this was the only occasion on which they were seen, it is likely that their numbers were limited.

One other species taken (two specimens, both indoors) was *Mansonia perturbans* Wlk. This species breeds attached to the roots of aquatic plants and cannot be destroyed by the usual methods of mosquito control. It is probable, however, that it is too few in number to warrant concern."

Ottawa, Ont.—During 1931, mosquitoes were scarcer in the Ottawa district than for many years past. This condition is closely related to abnormal weather, the year 1931 being one of the driest on record in the district. The total precipitation up to the end of November, 1931 was only 22.14 inches, or nearly 10 inches less than the 41-year average for this period. Mr. Twinn has given me the following notes:—

"Pools formed in the spring by melting snow and rain were less extensive than usual, the water quickly seeping away through the soil. As a result the snowpool species of mosquitoes, notably *Aedes stimulans* Wlk., and species of similar breeding habits, were scarce. The levels of the Ottawa river remained unusually low throughout the year the water failing to rise sufficiently high, even in spring, to cause the formation of the floodwaters in which the species *Aedes hirsuteron* Theo., develops. This condition resulted in a remarkable scarcity of the above species which in some seasons is an extremely annoying pest. During the summer, too, very little surface water collected, despite occasional heavy rains, and, as a consequence the usually abundant and ubiquitous rainpool mosquito, *Aedes vexans* Mgn., was present only in negligible numbers.

On the other hand, species of *Anopheles* (chiefly *A. maculipennis* Mgn., and *A. punctipennis* Say) which in recent years have been comparatively uncommon in the district, were more in evidence than usual, their larvae appearing in larger numbers than had previously been observed. Generally speaking, however, the adults were not sufficiently abundant to be considered a pest."

Lucerne-in-Quebec, Que,—Regarding mosquito control operations at Lucerne-in-Quebec in 1931, Mr. N. J. Atkinson reports that these were carried on "along much the same lines as in 1930 and with approximately the same measure of success. Owing to the press of other biological work only routine control operations received attention and no further biological studies were made.

The principal mosquito breeding areas of the district are of two types, the marginal flood plains along the Ottawa river and the woods, through much of which the water table is very high and the ground remarkably irregular, often with potholes or small ponds where these are least expected. The first area causes trouble only when the Ottawa rises to a sufficient height to flood the egg

beds, the second, deriving its water supply from melting snow and rain, is an annual breeding territory.

The season was unusally early and, while the April and May precipitations were 1.58 and 0.65 inches respectively above normal, the Ottawa river did not rise seriously, owing no doubt to the lack of snow during the previous winter. The maximum level was 134 feet above sea level on April 30, while normal flood level is 140 feet and is usually reached late in May. As a result the control operations were confined almost entirely to the wooded land and extended from April 16 to May 18 with further intermittent work until June 9. Approximately 3,000 gallons of oil were used.

During the latter part of April appreciable annoyance was caused by the females of Anophelines which had hibernated. This trouble persisted for about ten days and then, as was expected, disappeared. The adults were noticeably less abundant last autumn than in the fall of 1930 and little annoyance is expected this year."

Montreal, Que.—Certain sections of Montreal in and about Notre Dame de Grace, Westmount and Montreal West, have been troubled for some years by great numbers of mosquitoes of the species *Culex pipiens* L., which issue from an extensive sewage contaminated swamp formed by the Little St. Pierre river. This condition was studied several years ago by C. R. Twinn and W. St G. Ryan of the Entomological Branch who, in an article published in the 1915 Annual Report of the Quebec Society for the Protection of Plants, stated that satisfactory permanent control probably could be effected "only by diverting the source of sewage contamination, an operation involving the construction of a sewage disposal system at great initial cost. It is understood that such a plan is under consideration but its operation may not be in force for some years to come."

A $7,000.000 sewer is now under construction to take the flow of the Little St. Pierre river as well as to drain the entire district, and according to press reports it is hoped to have the work completed by late summer in 1932. With the completion of this sewer the source of a very serious pest affecting a considerable urban population will have been permanently removed, thus greatly improving the comfort and happiness of many thousands of people living in the affected area.

Other localities in Quebec.—From certain areas in Quebec province where our entomological service has established field stations for the study of forest insects, officers of the Department have reported but little annoyance from mosquitoes. Mr. M. B. Dunn, writing from Laniel, Que., on June 28, stated:

"There is the most extraordinary scarcity of blackflies and mosquitoes in the Laniel district during the present season, and the oldest inhabitants say that they have never seen anything like it. From my own experience I

would say that the numbers of these insects would be at the most 5 per cent of normal. Our camp is situated near the woods and even now at the height of the fly season we can sit on the porch in the evening and hardly get a bite, even after sunset, when in normal years both mosquitoes and blackflies would drive one from such a location in ten seconds." Mr. E. B. Watson reported:—"Mosquitoes and blackflies have been unusually scarce on the north shore of the Gulf of St. Lawrence and on the south shore in Rimouski County, Que. Their numerical strength was at least 10 per cent of normal."

Investigations in New Brunswick

Fredericton, N. B.—Mr. R. P. Gorham of our entomological laboratory at Fredericton, has informed me that mosquito control work was effected under the direction of the local City Engineer, areas comprising approximately 15,000 square yards being treated with used crank case oil. As a result of this work Mr. Gorham states that few mosquitoes were noticeable within the city; while outside of the city, they were reported to be "decidedly abundant." Four species were reared by Mr. Gorham, namely, *Aedes hirsuteron* Theo., *A. intrudens* Dyar, *A. cinereoborealis* F. & Y. and *A. canadensis* Theo. The first named species was decidedly the most abundant.

SUMMARY OF INSECT CONDITIONS IN CANADA, IN 1930 (1)

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The present summary of insect conditions in Canada is the second prepared for publication as an outcome of the Insect Pest Survey, of the Dominion Entomological Branch, the first, covering the year 1929, having appeared in *Scientific Agriculture*, in July, 1930 (3). As pointed out there, the Insect Pest Survey is maintained by the Entomological Branch, at Ottawa, under the direction of the Dominion Entomologist, for the purpose of bringing together and correlating reports dealing with insect conditions, received from reliable sources throughout the Dominion. The majority of these reports are submitted by entomologists on the staff of the Entomological Branch engaged in investigations on insect pests in the various provinces, but many also are received from provincial officials engaged in, or connected with, the study of insects. This summary has been prepared from a careful study of the above-mentioned reports.

As was the case in 1929, the year 1930 was characterised over much of the settled regions of the Dominion by sub-normal precipitation. This condition was more marked in Western Canada than in the East, particularly in Alberta and sections of southern Saskatchewan and British Columbia. The country as a whole, however, escaped the disastrous drought conditions that were such a conspicuous feature over a large part of the United States.

The upward trend in grasshopper populations, reported for 1929, continued during 1930, particularly throughout Western Canada, but despite this, in most sections, grasshoppers were not sufficiently abundant to cause crop damage of a serious character. It is anticipated, however, that if conditions continue favorable during 1931 and 1932, grasshoppers will increase to serious outbreak proportions in many parts of the Prairie Provinces and British Columbia. The two principal grasshopper species occurring throughout the West are the clear-winged grasshopper, *Camnula pellucida* Scudder, and the lesser migratory grasshopper, *Melanophus mexicanus* Saussure. In Eastern Canada, increased grasshopper abundance without serious crop injury was reported from Ontario and southern Quebec, the principal species involved being the red-legged grasshopper, *Melanoplus femur-rubrum* DeGeer.

Cutworms, in general, were not notably troublesome crop pests in Eastern Canada during 1930. In Nova Scotia, however, more damage was done by them to seedling plants than for several years past, and, in certain areas of

(1) Prepared by direction of the Dominion Entomologist.
(2) Assistant Entomologist, in charge, Insect Pest Survey.
(3) Volume X, pp. 754-758.

Quebec, injury was effected to the tobacco crop. In south-western Ontario, the dark-sided cutworm, *Euxoa messoria* Harr., caused considerable damage to tobacco, oats and corn, and the white cutworm, *E. scandens* Riley, also caused crop injury.

In Western Canada, in the Prairie Provinces, the pale western cutworm, *Agrotis orthogonia* Morr., and the red backed cutworm, *Euxoa ochrogaster* Gn., were pests of major importance. The pale western cutworm greatly extended its range in Saskatchewan and caused serious crop losses. In eastern Alberta, the Drumheller section was chiefly affected by the outbreak. The red-backed cutworm effected much damage to field and garden crops in western Manitoba and tree-grown sections of Saskatchewan and Alberta. In British Columbia, cutworms were scarce and, in general, caused less damage than for many years.

Very few reports of wireworm damage were received during 1930 from Eastern Canada, but in some sections of south-western Ontario and southern Quebec, quite severe injury was noted, particularly to tobacco. Other crops affected included corn, oats, tomatoes and potatoes. The prevalent species belong to the genera *Ludius* and *Melanotus*. Moderate to severe injury by wireworms was reported from various parts of Western Canada. Not much damage was done in Manitoba. In Alberta, although several species were abundant, crop losses were average or below average. In Saskatchewan, more damage than usual was done in gardens to such plants as potatoes, lettuce, tomatoes, etc., and although few reports of damage to field crops were received, it is believed that wireworms caused severe losses to grain in certain areas. The species *Ludius aereipennis* Kby., *L. tinctus* Lec., and *Cryptohypnus nocturnus* Esch., are included among the wireworm species of economic importance in the Prairie Provinces. In British Columbia, the damage to crops is annually severe, important injurious species being *Pheletes canus*, Lec. and *Limonius discoideus* Lec. During 1930, the damage was worse than usual, particularly severe injury occurring in the Okanagan, Fraser and Bulkley valleys.

White grubs were markedly injurious in sections of Quebec and eastern Ontario. A large area in southern Quebec was heavily infested by third-year grubs of *Phyllophaga anxia* Lec., and, in eastern Ontario, a heavy outbreak of second-year grubs occurred, much damage resulting to potatoes, corn, timothy and other field and garden crops. Elsewhere in Ontario there was no general outbreak, although damage to potato crops was reported. In the West, white grub injury to wheat and native sod was reported from a section of north-eastern Saskatchewan. In British Columbia, the numbers and depredations were about normal. Flights of June beetles were noted in sections of Prince Edward Island and New Brunswick, and locally in southern Quebec and southern Manitoba.

In Ontario, as a whole, the European corn borer, *Pyrausta nubilalis* Hbn., again showed a decrease in the intensity of infestation, particularly in the area in which the provincial government maintains compulsory control (all or

parts of 24 counties). This is especially true over the greater part of the area where corn is a major crop. The infestation in counties along the eastern end of lake Ontario showed a tendency to increase. This was particularly noticeable in Hastings and Prince Edward counties. Along the St. Lawrence and Ottawa rivers the infestation, on the average, continued light and more or less stationary. In areas throughout the province where field corn is of little importance, a definite upward trend in the infestation of sweet corn was noted. In Quebec, in eleven counties examined, eight showed definite borer increases and three remained stationary. The infestations are relatively light, many fields showing no infestation whatever. The highest single infestation record did not exceed ten per cent. In New Brunswick, no sign of the borer was found in Queen's county, but it was found again in Sunbury and Charlotte counties. It also was found for the first time in King's county. Although 580 fields of corn in the province were examined, the borer was discovered only on six farms. In Nova Scotia, the borer again occurred in the counties of Yarmouth, Digby, Annapolis and Kings, and one additional county, namely, Cumberland. The insect appears to be increasing somewhat in this province.

The corn ear worm, *Heliothis obsoleta* Fab., occurred in moderate numbers in the Maritime Provinces and Ontario, but was not important as a pest.

The Colorado potato beetle, *Leptinotarsa decemlineata* Say, was not more than normally injurious in most parts of the Dominion although a moderate increase in abundance over 1929 was reported from parts of the Maritimes and the Prairie Provinces. In the south-eastern corner of British Columbia, the only part of that province infested, the insect continues to be kept well under control and no further spread was recorded during the year.

Reports indicate an increased abundance of wheat stem sawfly, *Cephus cinctus* Nort., in the Prairie Provinces, but crop damage generally was less severe than in 1929. In Manitoba, the area infested in the western half of the province, was greater than in the previous year, due to an increase in the acreage of spring wheat, but crop loss was light. In Saskatchewan, although the sawfly infestation was believed to be generally higher than in 1929, the average loss showed a material decrease. In Alberta, where the insect has been increasing steadily during the past few years it was more abundant than since 1926. Less trouble was experienced than had been anticipated, although it is thought that drought conditions caused the losses to be underestimated.

The stem maggot, *Hylemyia cerealis* Gill., caused marked damage to isolated fields of spring wheat in a number of localities in southern Alberta. It was last reported as a pest in the province in 1923. Reports of stem maggot injury to wheat apparently typical of the wheat stem maggot, *Meromyza americana* Fitch, were also received from widely scattered points in Saskatchewan.

Judging from the paucity of reports, root maggots were not a particularly serious crop pest in Eastern Canada. In Ontario, the onion maggot, *Hylemyia antiqua* Mgn., and the cabbage maggot, *H. brassicae* Bouché, were considered

as less destructive than in 1929, although in certain southern localities in the province, the latter species caused considerable injury to cabbage, cauliflower and garden radishes. In the West, in Saskatchewan, injury by the cabbage maggot was accentuated by drouth conditions. This species was also injurious in sections of Alberta. In British Columbia, both the cabbage maggot and the onion maggot are believed to have caused rather more damage than is usually the case. In addition to the above, the seed corn maggot, *H. cilicrura* Rond., was destructive to seed corn and beans in sections of southern Ontario, and to seed beans, locally, in southern Manitoba.

No marked difference from average in the abundance and destructiveness of the imported cabbage worm, *Pieris rapae* L., was indicated by reports received from sections of Eastern Canada. In the West, this insect continued to effect widespread damage to cabbage and cauliflower in the Prairie Provinces, and appears to be increasing. In British Columbia it was definitely less abundant than usual.

In the Dominion west of Manitoba, the diamond-back moth, *Plutella maculipennis* Curt., developed in outbreak form during 1930. In Saskatchewan, particularly western Saskatchewan, and in Alberta, considerable acreages of cabbage, cauliflower and turnip were quite severely damaged or destroyed. To some extent the insect was beneficial as in addition to cruciferous crops it attacked wild mustards in grain fields. Its habit of pupating in cocoons on heads of wheat, however, occasioned some alarm among farmers. In British Columbia, the insect was quite extraordinarily abundant and did extensive damage, particularly in south-eastern British Columbia. Elsewhere in the Dominion the species was not important.

The serious outbreak of tarnished plant bug, *Lygus pratensis* L., that occurred in 1929, in Ontario, was not repeated in 1930, the insect being comparatively scarce. In New Brunswick, it was reported as more injurious than in other years, and it was also noted as particularly abundant in sections of Nova Scotia attacking apple, potato, garden flowers and other plants. In the Okanagan valley, British Columbia, it again caused much damage in orchards by attacking pear and apple buds, and by producing on peaches a malformation known as "cat-facing". The damage was most serious in orchards under cover crops.

Reports indicate that flea beetles of several species were again troublesome pests in various parts of the Dominion. The potato flea beetle, *Epitrix cucumeris* Harr., was prevalent in sections of the Maritime Provinces and southern Ontario. Cabbage flea beetles, *Phyllotreta vittata* Fab., caused considerable injury to seedling plants locally in New Brunswick, and the species *P. albionica* Lec., was responsible for serious damage to cruciferous crops in British Columbia. The horse-radish flea beetle, *P. armoraciae* Koch., was abundant in parts of Ontario and also locally in New Brunswick. The smartweed flea beetle, *Systena hudsonias* Fors., attacked a wide range of vegetables and flowering plants in Ontario; and, in southern sections of the same province, the pale-striped flea

beetle, *S. taeniata* Say, caused damage to sugar beets and canning factory beans. The hop flea beetle, *Psylliodes punctulata* Melsh, was reported injuring tobacco in beds, locally in southern Ontario, and, what presumably was this species, attacked sugar beets in sections of southern Alberta. The species, *Disonycha triangularis* Say, was more numerous than usual in southern Manitoba and seriously interfered with the commercial growing of sugar beets in the Winnipeg district. In wooded areas south of Annapolis Royal, Nova Scotia, the alder flea beetle, *Haltica bimarginata* Say, in some instances completely defoliated alders.

As usual the western blister beetle, *Lytta nuttalli* Say, was abundant in the Prairie Provinces, attacking caragana, beans and vetch.

The results of scouting during 1930 gave further evidence to support the belief that the Mexican bean beetle, *Epilachna corrupta* Muls., is not able to survive climatic conditions in Canada. Small local infestations have been discovered in a few localities each year since 1927. In each case such infestations have disappeared the following season, and, during 1930, only two small infestations were noted in the southern part of the province.

In sections of Manitoba and Saskatchewan the beet webworm, *Loxostege sticticalis* L., was very abundant attacking principally weeds, such as lamb's quarters and Russian thistle. In Saskatchewan, in addition to the weeds, it effected serious damage in vegetable gardens.

Many reports of potato stem borers, *Gortyna micacea* Esp., attacking potatoes, rhubarb, etc., were received in Nova Scotia. In New Brunswick, the iris borer, *Macronoctua onusta* Grote., was found in the province for the first time, injuring wild iris in Kent county. A local infestation of the sunflower maggot, *Straussia longipennis* Weid., also was found in the above province at Fredericton. Tobacco stalk borers, *Crambus luteolellus* Clem., and associated species, caused considerable damage to tobacco and corn in south-western Ontario. In Manitoba, the columbine borer, *Papaipema purpurifascia* G. & R., was a rather widespread and troublesome pest to columbines.

An infestation of the false chinch bug, *Nysius ericae* Schill., developed in sections of southern Alberta, the insects attacking spring wheat. The damage done was not important. For the first time this species was recorded as doing serious damage in British Columbia, where in the Kootenays it attacked potatoes and cherries.

The only reports received concerning the hessian fly, *Phytophaga destructor* Say, were from Manitoba and Saskatchewan, where the insect was reported as scarce, and from Vancouver Island, British Columbia, where it was said to have done local damage to fall wheat in the Saanich peninsula.

The European earwig, *Forficula auricularia* L., which first came into prominence as an economic pest in 1924, in coastal sections of British Columbia, was greatly reduced as a pest during 1930 as a result of local control campaigns and the killing effect of severe winter temperatures on the over-wintering adults. The infested area, however, is slowly extending in the coastal cities.

Moderate outbreaks of the zebra caterpillar, *Ceramica picta* Harr., were noted from sections of Nova Scotia, New Brunswick, Quebec and Ontario. In general the damage effected was not important, with the possible exception of the outbreak in Nicolet, Drummond and Arthabaska counties, in Quebec, where quite severe injury was done to a variety of field crops.

Reports from the Maritime Provinces and Ontario show that, in general, the carrot rust fly, *Psila rosae* Fab., was less than usually destructive.

In southern Ontario, tobacco worms, *Protoparce quinquemaculata* Haw., were more abundant than during the past few years, feeding on tobacco and tomatoes.

In certain localities in New Brunswick, the cucumber beetle, *Diabrotica vittata* Fab., markedly increased in abundance over 1929 and caused severe damage in market gardens to cucumber and squash. Elsewhere in the Maritimes, and in Quebec and Ontario, this pest was about normal in abundance and was not particularly injurious.

In southern Manitoba, many complaints were received of the destruction of rose buds by the rose curculio, *Rhynchites bicolor* Fab. In British Columbia, species of sawflies which attack roses were reported to be unusually abundant.

An outbreak of aphids on cruciferous crops, notably the turnip aphid, *Rhopalosiphum pseudobrassicae* Davis, resulted in much damage in sections of Nova Scotia and southern Ontario. There was also a heavy aphid infestation on cruciferous crops in the Victoria district, British Columbia. The pea aphid, *Macrosiphum pisi* Kalt., was abundant on peas locally in southern Quebec, and in the Ottawa district, Ontario. For the first time, the aphid known as the green bug, *Toxoptera graminum* Rond., was found in outbreak numbers in the Prairie Provinces, where it appeared late in summer, in sections of western Manitoba and eastern Saskatchewan, and effected material damage to late sown oats. The English grain aphid, *Macrosiphum granarium* Kby., was also common on oats, and, to a lesser extent, on wheat, in sections of these two provinces.

Although the onion thrips, *Thrips tabaci* Lind., was present more or less throughout Ontario, it caused less damage than was anticipated. The gladioli thrips, apparently *Taeniothrips gladioli* Moulton, caused much damage to the foliage and spikes of gladioli in Ontario. This insect was also a pest in 1929. In British Columbia, a species of thrips was thought to be responsible for carrying a fruit blight which caused material damage to raspberries and loganberries in coastal sections of the province.

A more severe outbreak of the spinach leaf miner, *Pegomyia hyoscyami* Panz., than had occurred for many years, developed in the Niagara district, Ontario, in May and June, and caused important damage to the spinach crop, and injury to beets and mangolds. This species was also a serious pest of garden spinach and beets, locally, on southern Vancouver Island, British Columbia.

In Nova Scotia, and in the St. John river valley, New Brunswick, there was a further decline in the abundance of the eye-spotted budmoth, *Spilonota ocel-*

lana D. & S., but in untreated orchards, in certain other sections of New Brunswick, heavy infestations occurred. In Ontario, this budmoth caused considerable damage in some localities, but the situation in general appears to be gradually improving. In Quebec, the species is reported as increasing about Montreal and decreasing in the Quebec district.

Heavy local infestations of the plum curculio, *Conotrachelus nenuphar* Hbst., were reported from sections of Nova Scotia and New Brunswick. In southern Quebec, the insect is reported to have been very injurious for a number of years, and in Ontario, although the numbers of this species were about normal early in the season, in the autumn it appeared to be scarce. The apple curculio, *Tachypterellus quadrigibbus* Say, continued to be the most troublesome insect in many orchards in southern Quebec.

The codling moth, *Carpocapsa pomonella* L., was unusually injurious in the Maritime Provinces and Ontario, particularly in neglected orchards. In the latter province, there was more than the usual amount of side-worm injury. In Quebec, the insect is either stationary in abundance, or increasing. In orchard sections of British Columbia, the codling moth was unusually scarce and less injurious than for many years.

The apple maggot, *Rhagoletis pomonella* Walsh, was present in the Maritime Provinces, particularly in uncared for orchards. In southern Quebec, this insect occurred throughout apple growing districts, the amount of damage caused by it varying with the efficacy of control measures. In Ontario, the infestation was apparently lighter than at any time during the past few years. In sections of the Maritimes, blueberries were infested by larvae of what is believed to be this or an allied species.

The apple aphid, *Aphis pomi* DeG., which appeared in outbreak numbers in parts of Eastern Canada, in 1929, was scarce in 1930, and caused comparatively little damage. Considerable fruit injury was reported, however, from New Brunswick, and the species was also noted as troublesome in the Okanagan valley, British Columbia. The rosy apple aphid, *Anuraphis roseus* Baker, was moderately abundant in the Annapolis valley, Nova Scotia, causing considerable damage in some orchards. This species and the black cherry aphid, *Myzus cerasi* Fab., were of minor importance in Ontario. The currant aphid, *M. ribis* L., was normally abundant and destructive in Manitoba and Saskatchewan. In British Columbia, the woolly apple aphid, *Eriosoma lanigera* Hausm., was scarce during the season, but all other species were unusually abundant.

Infestation records taken in connection with the oriental fruit moth, *Laspeyresia molesta* Busck, revealed a marked and gratifiying decrease in the amount of injury by this species in most of the peach orchards in the Niagara district, Ontario. This reduction is believed to have been brought about by several factors, including predators and parasites, and unusually warm, dry weather conditions.

The peach twig borer, *Anarsia lineatella* Zell., which is usually injurious to peaches and apricots in the southern Okanagan valley, British Columbia, was very scarce during 1930. An unusual pest of peaches is the gray snout beetle, *Anametis granulatus* Say, which attacked the buds of young peach trees, locally, in southern Ontario. It also caused slight injury in some apple orchards by devouring the bark from the smaller twigs and branches.

Injury in Nova Scotia orchards by the oyster shell scale, *Lepidosaphes ulmi* L., was negligible in 1930. In New Brunswick, the insect apparently decreased in some sections, but a number of severe infestations affecting fruit occurred where control measures were neglected. In British Columbia, where it is one of the major pests in apple orchards, its abundance was below normal. The San Jose scale, *Aspidiotus perniciosus* Comst., increased considerably in the Niagara district, Ontario, favoured by the warm dry season. A light infestation of the soft scale, *Eulecanium fitchii* Sign., occurred on respberries near Vancouver, British Columbia. Hitherto this species was known to occur only in Ontario where it was first recorded in 1901.

The pear slug, *Eriocampoides limacina* Retz., was abundant in the Maritime Provinces, in some sections defoliating pear, cherry and plum trees, particularly where spraying was not practised. Heavy local infestations also occurred in southern Quebec. The species, with local exceptions, was scarce generally throughout British Columbia.

The pear psylla, *Psyllia pyricola* Forst, caused little injury in southern Ontario this year, and even unsprayed orchards were less heavily infested than usual.

Several species of leaf rollers were present in moderate numbers in orchard sections of Eastern Canada. The fruit tree leaf roller, *Cacoecia argyrospila* Wlk., although materially destructive, locally, in Ontario, was less important over the province as a whole, than during the previous two years. The species *Cacoecia semiferana* Wlk., and *Pandemis limitata* Rob., which occur on fruit trees in Norfolk county, Ontario, also were less numerous than in 1929. The red banded leaf roller, *Eulia velutinana* Wlk., occurred in small numbers, and there was a light general infestation of the oblique-banded leaf roller, *Cacoecia rosaceana* Harr., in fruit-growing sections of the province. The latter species and the white-triangle leaf roller, *Cacoecia persicana* Fitch, occurred in sections of Nova Scotia, in about their usual numbers, without causing material damage. The gray-banded leaf roller, *Eulia mariana* Fern., caused considerable damage to fruit in the Berwick district, Nova Scotia, and is slowly spreading in the Annapolis valley. The dusky leaf roller, *Amorbia humerosana* Clem., is slowly becoming established in sod orchards in the valley, particularly at the western end.

Apple leaf hoppers, *Typhlocyba pomaria* McA., *Empoasca fabae* Harr. and *E. mali* LeB., were generally abundant in fruit-growing sections of the Maritime Provinces and Ontario. During the year, weather conditions were favourable to

the increase of grape leaf hoppers, *Erythroneura* spp., in the Niagara peninsula, Ontario, and an outbreak is expected in 1931.

The lesser apple worm, *Laspeyresia prunivora* Walsh, which is generally present in small numbers in New Brunswick, decreased somewhat in 1930, particularly where increases were noted in 1929. In British Columbia, this species, which in some seasons causes severe damage to apples in the Okanagan valley, was unusually scarce.

The apple seed chalcid, *Syntomaspis druparum* Boh., was quite prominent in many parts of the Annapolis valley, Nova Scotia. In New Brunswick, the apple leaf sewer, *Ancylis nubeculana* Clem., increased considerably, particularly in sections of Sunbury, Northumberland and Kent counties. The infestations are not yet serious.

Winter eggs of the apple sucker, *Psyllia mali* Schmid., were prevalent in Nova Scotia in the spring of 1930, but damage occurred in only a few isolated orchards, due to general spraying practices.

In Nova Scotia, the apple and thorn skeletonizer, *Hemerophila pariana* Clerck, decreased in numbers over 1929; in New Brunswick, although local outbreaks were noted, it was not an abundant pest in thoroughly sprayed orchards. In Ontario, foliage injury was conspicuous in August in the infested area, but the insect does not appear to have increased in numbers since its first appearance in 1929. This species has been recorded from every province in Eastern Canada with the exception of Prince Edward Island.

Moderate infestations of the cigar case-bearer, *Haploptilia fletcherella* Fern., were reported from various fruit-growing sections of Eastern Canada and British Columbia. The damage effected was not important, and, in the provinces of Nova Scotia and Ontario, was recorded as less than in 1929.

In British Columbia, the cherry fruit fly, *Rhagoletis fausta* O. S., was reported as spreading from its original area of infestation around Kootenay Lake, in the south-eastern portion of the province.

The cherry fruit worm, *Grapholitha packardi* Zell., continues to effect damage to cherries on Vancouver Island, British Columbia.

Green fruit worms of several species were more common than usual in the Maritime Provinces.

In the Prairie Provinces, particularly in Alberta and Saskatchewan, the currant fruit fly, *Epochra canadensis*, was a serious pest of currants and gooseberries, destroying a considerable proportion of the crop in these two provinces. In British Columbia, this species appeared to be less abundant than for many years. The imported currant worm, *Pteronidea ribesi* Scop., caused little more defoliation of currants than usual, in Nova Scotia, and was very scarce in New Brunswick. It was also reported as less abundant in 1930, than ordinarily is the case, in Saskatchewan and British Columbia. Considerable local injury to black currants by the imported currant borer, *Synanthedon tipuliformis* L., was noted in British Columbia. The currant span worm, *Itame ribearia* Fitch, was reported as less abundant than for several years in southern Alberta.

In sections of southern Quebec and Ontario the raspberry cane borer, *Oberea bimaculata* Oliv., was more common than usual, and caused much injury to the tips of raspberries and roses. A general outbreak of the raspberry fruit worm, *Byturus unicolor* Say, occurred in the Niagara peninsula, Ontario, and caused damage to the raspberry crop.

Important damage to stawberries in parts of Prince Edward Island was done by strawberry weevils, *Anthonomus signatus* Say, which cut a large percentage of the fruit buds. To a lesser extent the buds of raspberries were also attacked. The insect was also reported abundant in the St. John river valley, New Brunswick.

The ugly nest caterpillar, *Cacoecia cerasivorana* Fitch, occurred in abundance on choke cherries in southern sections of New Brunswick and Manitoba. The insect is not of much importance owing to the fact that it confines its attacks to the above host plant.

Throughout southern sections of Ontario the cotton moth, *Alabama argillacea* Hbn., appeared in conspicuous numbers late in September.

In south-western Ontario, the rose chafer, *Macrodactylus subspinosus* Fab., showed a considerable increase in abundance over 1929, and did much damage to rose, apple, peach, cherry, grape and ornamentals.

Spider mites were abundant and destructive in many parts of Canada during 1930, particularly in the Prairie Provinces. Winter eggs of the European red mite, *Paratetranychus pilosus* C. & F., were more prevalent than usual in the Annapolis valley, Nova Scotia, and in orchard sections of New Brunswick. The mite, however, rapidly diminished in numbers, in mid-summer, in Nova Scotia, apparently largely owing to the predatory activities of a species of plant bug. In New Brunswick, although infestations had increased rapidly during the past two years, in 1930 there was a decided decrease in many sections. In Ontario, this species of mite was less abundant than during the past several years. The common red spider mite, *Tetranychus telarius* L., rather heavily infested raspberries in many parts of the Niagara district, Ontario. In the Prairie Provinces, this species was particularly injurious to small fruits, such as currants and raspberries, and attacked many other plants such as tree shrubs and garden flowers and vegetables.

In Saskatchewan, the spider mite, *Paratetranychus ununguis* Jac., was one of the most serious shade tree pests of the season, particularly affecting spruce. The silver leaf mite, *Phyllocoptes schlechtendali* Nal., occurred in greater numbers in the Niagara district, Ontario, than in any known previous year, in peach orchards. The clover mite, *Bryobia pratensis* Garm., occurred in orchards in Nova Scotia, and was also troublesome in dwellings in the Vernon district, British Columbia, early in the season.

Minor outbreaks of the pear leaf blister mite, *Eriophyes pyri* Pgst., were reported in sections of Sunbury, Northumberland and York counties, New Brunswick, and there are indications that this species is increasing in orchards in British Columbia where the dormant lime-sulphur spray is not applied.

Reports indicate that the eastern tent caterpillar, *Malacosoma americana* Hbn., is increasing throughout the Maritime Provinces and probably throughout Eastern Canada, reports of its depredations to the foliage of wild and cultivated fruit trees and shade trees also being received from sections of southern Quebec and Ontario. In British Columbia, the very severe tent caterpillar outbreak of 1929 in the Lower Fraser valley and on Vancouver Island was repeated. Over the southern mainland, the forest and eastern tent caterpillars, *Malacosoma disstria* Hbn., and *M. americana* Fab., did material damage to various deciduous trees. On Vancouver Island, the principal species were *M. pluvialis* Dyar, and *M. erosa* Stretch. In north-western Saskatchewan, north of Battleford, the forest tent caterpillar outbreak continued, but the eastern tent caterpillar appeared to be less abundant than in 1929.

The white-marked tussock moth, *Hemerocampa leucostigma* S. & A., was again present in conspicuous numbers in the Maritime Provinces, but in New Brunswick was noted as less abundant than in 1929. A tussock moth believed to be this species was found attacking fir, white spruce and alder in sections of Nova Scotia. The rusty tussock moth, *Notolophus antiqua* L., was again abundant in Nova Scotia but less injurious than the white-marked tussock. In British Columbia, the tussock moth, *Hemerocampa pseudotsugata* McD., has defoliated large areas of Douglas fir in several sections of the Province.

An increase in the abundance of the fall webworm, *Hyphantria cunea* Dru., was noted in many sections of Eastern Canada. The species caused more defoliation than usual on fruit trees and various kinds of shade trees and ornamentals. In coastal sections of British Columbia its numbers showed a decided decrease during 1930.

The satin moth, *Stilpnotia salicis* L., was found for the first time in Eastern Canada, in the Maritime Provinces, during 1930. Two local infestations were discovered, one on willow at Annapolis Royal, Nova Scotia, on June 25, and the other on poplar at Moncton, New Brunswick, on July 3. Following the finding of this pest in the above areas a survey was made in the Maritime Provinces. Infestations were revealed at Sussex and St. Andrews, New Brunswick, and, in Digby and Yarmouth counties, Nova Scotia, and in the eastern part of the latter province in the vicinity of Amherst. Hitherto this insect was known to occur only in British Columbia, where it was first discovered in July, 1920. In the latter province, it has continued to spread in the Lower Fraser valley and on Vancouver Island.

The outbreak of the hemlock looper, *Ellopia fiscellaria* Gn., which developed on the north shore of the St. Lawrence, in Quebec, between the Bersimis and Pentecote rivers, and was severe in 1928, declined in 1929, and subsided entirely during 1930. The extensive rainfall in this section during the past two years is believed to have been an important factor in the decline of the insect. A mild outbreak of this species occurred during 1930 in sections of Nova Scotia. A closely allied species of looper, *Ellopia somniaria* Hulst, has done very exten-

sive damage to hemlock on the British Columbia coast, but is definitely on the decline. Another species of insect effecting hemlock is the hemlock bark maggot, *Chilosia alaskensis* Hemler. This species is reported over all the southern mainland of the British Columbia coast section, and in the Vancouver district. A high percentage of hemlocks are infested.

Bark beetles of the genus *Dendroctonus* are on the increase over large areas in British Columbia, and during 1930 were unusually destructive. Throughout southern sections of the province the species *Dendroctonus monticolae* Hopk., attacked western yellow pine and lodgepole pine, and areas of dead trees due to this beetle are particularly noticeable this season. In Eastern Canada, the species, *Dendroctonus piceaperda* Hopk., continued to attack areas of white spruce in sections of Nova Scotia.

The black-headed tip moth, *Peronea variana* Fern., continued to effect material damage to balsam and white spruce over an area of about 200 square miles on Cape Breton Island, Nova Scotia. An outbreak of this species also occurred over a large part of the southern mainland of the British Columbia coast section, attacking hemlock, balsam, Douglas fir and sitka spruce.

Further scouting for the brown-tail moth, *Nygmia phaeorrhoea* Don., in Nova Scotia, revealed no signs of this pest, and supports the belief that the brown-tail moth has been exterminated in Canada. Scouting for the gypsy moth, *Porthetria dispar* L., in the Eastern Townships of Quebec, where a local outbreak was discovered in 1924, indicates that this species also has been completely stamped out.

The outbreak of spruce budworm, *Cacoecia fumiferana* Clem., in the Westree district, north of the Georgian Bay, Ontario, centering about the headwaters of the Montreal, Spanish, Wanapitae, Sturgeon, Mattagami and Groundhog rivers, apparently is continuing to spread very slowly in a southwesterly direction. About 5000 square miles of balsam forest are infested. Elsewhere in Eastern Canada this species did not appear in outbreak form. In British Columbia, on Vancouver Island, the outbreak of spruce budworm on Douglas fir, which last year was recorded as subsiding, has now terminated completely. In the Cariboo district, a widespread infestation which has been present for many years continues, and was severe in 1930. An outbreak was also reported at Lillooet, but has not yet been investigated.

The spruce sawfly, *Neodiprion lecontei* Fitch, severely defoliated Austrian pine in the vicinity of Plantaganet, Ontario. In northerly sections of Saskatchewan, this species was more common than in 1929, and did considerable damage to balsam fir. In Manitoba, parasites continued to reduce its numbers. Species of *Neodiprion* were abundant on jack pine in the Biscotasing district, Ontario, and appear to be increasing. So far the infestation is not very severe and few trees have been killed. Jack pine is also suffering serious defoliation by a species of *Neodiprion* along the north-west arm of Kippewa lake, Quebec.

The yellow headed spruce sawfly, *Pachynematus ocreatus* Hart., is widely distributed in Manitoba and injurious to the foliage of spruce. It was also recorded from a number of localities in Saskatchewan, where, in some instances, it caused severe defoliation. In the southern part of the Gaspe peninsula, Quebec, sawflies, believed to be this species,* caused moderately severe defoliation to spruce over a rather wide area. In Ontario, sawflies defoliated spruce hedges along the C.P.R. line between Biscotasing and Chapleau.

Severe foliage injury to larch by the larch sawfly, *Lygaeonematus erichsoni* Hart., occurred in southern Quebec between Clarenceville and Missisquoi Bay, and probably over a wider territory. The species was also common on larch throughout Richmond county, Nova Scotia, and in the Biscotasing and St. Williams districts, Ontario. An absence of injury by the larch sawfly was reported from New Brunswick, and a reduction in numbers was noted in Saskatchewan.

The larch case-bearer, *Haploptilia laricella* Hbn., which was severe on larch in Nova Scotia, during 1929, diminished preceptibly in numbers in 1930. It also decreased considerably in New Brunswick. In sections of southern Quebec, it again caused important foliage injury, and, in Ontario, it was exceptionally abundant on all larch stands inspected.

The poplar leaf-folding sawfly, *Pontania bozemani* Cooley, was more abundant in southern Alberta than during the past six years, but appeared to do no serious damage. It was also rather abundant generally in Saskatchewan.

The lilac leaf miner, *Gracilaria syringella* Fab., continued to disfigure the foliage of lilacs in Ontario and coastal sections of British Columbia. In the former province it appeared to be less prevalent than in 1929. The birch sawfly leaf miner, *Phyllotoma nemorata* Fall., again appeared in outbreak form in New Brunswick, but the infestation appears to be decreasing. The European birch leaf miner, *Fenusa pumila* Klug., continued as a pest of importance over a wide area in Quebec. The local outbreak of the spruce leaf miner, *Taniva albolineana* Kearf., which occurred at Kingsville, Ontario, in 1929, completely subsided during the season under review.

An unusually severe outbreak of the birch leaf skeletonizer, *Bucculatrix canadensisella* Chamb., occurred throughout the Maritime Provinces, the foliage of affected trees turning yellow and then brown early in August. This species was also more abundant than for several years past in the Muskoka district, Ontario, and severe local outbreaks were reported from southern Quebec. It was also noted as defoliating birch trees in sections of Manitoba and Saskatchewan.

In British Columbia, the European scale, *Eulecanium coryli* L., which attacks deciduous trees and shrubs, appears to be increasing seriously in the Vancouver district and up the Fraser valley. Observations indicate that *Blas-*

* Since identified as a European sawfly, *Diprion polytomum* Hart.

tothrix sericea, a parasite of the above scale, introduced from England during the past three years, is becoming well established.

The beech scale, *Cryptococcus fagi* Baerns., infests beech practically all over Nova Scotia, and in some sections is seriously affecting the health of, or destroying the trees. This scale is spreading slowly in New Brunswick, where it is established in outbreak form in Westmoreland and Albert counties.

The pine needle scale, *Chionaspis pinifoliae* Fitch, is widely distributed in Manitoba and caused injury to spruce at various points in the province. It also showed a decided increase in Saskatchewan, where it is becoming a serious menace to spruce and is said to be widespread.

Monochamus beetles of the species *Monochamus scutellatus* Say and *M. notatus* Dru., were reported more abundant than in 1929 in the Kippewa district, Quebec, affecting spruce and pine logs and lumber. The infestation was widespread but not heavy.

The maple leaf cutter, *Paraclemensia acerifoliella* Fitch, occurred in greatly reduced numbers, compared with previous years, in Ontario and southern Quebec. The reduction of this species to an endemic status in 1930 has been brought about by bacterial disease, parasites, predators and unfavourable weather conditions.

The pitch twig moth, *Petrova comstockiana* Fern., infested and destroyed about 5 per cent of the twigs of jack pine in the Kippewa lake district, Quebec. The infestation is considered as probably 50 per cent lighter than in 1929.

The fall cankerworm, *Alsophila pometaria* Harr., badly defoliated large numbers of shade trees, elm and Manitoba maple, in the Winnipeg district and other points in southern Manitoba. It was of no material importance this year in the Maritime Provinces.

The boxelder leaf roller, *Gracilaria negundella* Cham., increased decidedly, during 1930, in Manitoba and Saskatchewan, and effected considerable damage to boxelder.

Reports of injury by the poplar and willow borer, *Cryptorhynchus lapathi* L., were received from Sussex, New Brunswick, and the Vancouver and Riske Creek districts, British Columbia.

The poplar borer, *Saperda calcarata* Say, which is widely distributed in Quebec, was prevalent in the Montreal and Hemmingford districts, causing injury to poplars. A severe infestation was also noted locally in Stormont county, Ontario.

The cottonwood leaf beetle, *Lina scripta* Fab., was moderately abundant on willows at St. John and Fredericton, New Brunswick, and the aspen poplar leaf beetle, *Lina tremulae* Fab., was reported on the increase in Manitoba. In the latter province willows over a wide area from Dauphin to Swan River were defoliated by the willow leaf beetle, *Galerucella decora* Say.

The species *Pteronidea cornelli* Marl., was reported as injurious to Russian poplars at Saskatoon, Saskatshewan. This is the first record of this species in Canada.

Several species of aphids of the genus *Adelges* were abundant on spruce and pine in New Brunswick, and on spruce and larch in Saskatchewan. They are increasing in importance in the latter province. The black willow aphid, *Melanoxantherium smithiae* Mon., was abundant in Saskatchewan and Alberta, particularly on poplars. The outbreak which is of three years standing in Alberta, is reported to have caused the death of many groves of trees. The boxelder aphid, *Chaitophorus negundinis* Thom., caused more damage than usual in the Prairie Provinces. In addition, a heavy infestation of elm aphid, *Schizoneura americana* Riley, resulted in the severe disfigurement of trees in Alberta and Saskatchewan. Gall-forming aphids were destructive on poplar in the latter provinces.

The carpenter worm, *Prionoxystus robinae* Peck., was injurious to soft maples in southern Quebec. A heavy and rather widespread infestation of this species was reported from British Columbia, at Craig Lodge and Lillooet, on cottonwood.

Many walnut and butternut trees were quite severely defoliated by the walnut caterpillar, *Datana integerrima* G. & R., in south-western Ontario. In the Ottawa district, this species was scarce.

The outbreak of the lime tree looper, *Erannis tiliaria* Harr., which was quite severe in the Brandon Hills, Manitoba, in 1928, affecting a variety of deciduous trees, apparently has entirely subsided. This species was reported as abundant near Ottawa, Ontario, on maple and linden, and appears to be increasing.

Buprestid beetles of the genus *Brachys* were common on the foliage of white oaks and linden in the Hemmingford and Oka districts, Quebec. This species was also abundant in the vicinity of Ottawa, Ontario, feeding on the foliage of various hardwoods and doing considerable damage.

Species of flies attacking horses and cattle were reported as a serious pest to livestock in Nova Scotia, particularly in the eastern part of the province, about Amherst. In Manitoba, an unusually severe outbreak of the stable fly, *Stomoxys calcitrans* L., occurred over an extensive area, affecting cattle, horses, dogs and man. The horn fly, *Lyperosia irritans* L., was abundant in eastern Manitoba affecting cattle.

Horse flies (Tabanidae) were abundant in Manitoba in the vicinity of bogs and marshes. In British Columbia, reports of tabanids were received from a number of localities. Biting leptids were annoying at higher elevations in the latter province.

Black flies of the family Simuliidae were complained of from a number of localities, during 1930, in districts near the Saskatchewan river, Saskatchewan. The attacks of these flies on livestock were serious, many deaths occurring among cattle, in one locality, at least. In British Columbia, notably in the Kootenay and Kamloops districts, black flies were injurious to livestock and also attacked man.

The ox warble fly, *Hypoderma bovis* DeG., appears to be more troublesome than usual in eastern Manitoba, the flies causing gadding of cattle, and the grubs injury to hides. Gad flies were reported annoying cattle on the Riske Creek range, British Columbia.

Bot flies, *Gastrophilus* spp., were abundant in Manitoba, and caused much annoyance to horses in the Riske Creek range section of British Columbia.

Mosquitoes were troublesome in many sections of Eastern Canada, although probably to a lesser extent than is the case in some years. On the western prairies, as in 1929, they were a much less troublesome pest than is usually the case. In British Columbia, mosquitoes were a pest in the Kootenay district and also at the coast, but in the Kamloops district and the interior they remained scarce.

A severe infestation of ticks, *Dermacentor andersoni* Stiles (*venustus* Banks), on cattle, occurred in the interior of British Columbia, in the spring, and resulted in many cases of tick paralysis. Outbreaks of ticks also occurred on Vancouver Island, north of Victoria, and in Ontario, on an Indian reservation in Middlesex county.

Reports of the presence of bedbugs and fleas in dwellings were received from various sections of the Dominion. The common fleas found in houses, attacking both man and animals are the cat and dog fleas, *Ctenocephalus felis* and *C. canis*. In 1930, an infestation of the human flea, *Pulex irritans* L., was found in a dwelling in New Westminster, B.C., and, in Ontario, the European chicken flea, *Ceratophyllus gallinae* Schrank, was reported attacking the inmates of a dwelling in Bruce county.

Ants were troublesome in many parts of Canada, particularly in sections of the Prairie Provinces and British Columbia, infesting lawns and invading houses. In the latter province considerable damage was done by ants to house timbers in Vancouver.

Wasps, which in 1929 were exceptionally abundant in British Columbia, were scarce in 1930.

The usual complaints of infestation or damage by such household insects as clothes moths, carpet beetles, fish moths, dermestid beetles, etc., were received from various parts of the Dominion during the year.

Various species of insects were reported infesting stored grain and other cereals and their products, particularly in sections of southern Ontario and the Prairie Provinces. The chief species involved included the saw-toothed grain beetle, *Silvanus surinamensis* L., the granary weevil, *Calendra granaria* L., the confused flour beetle, *Tribolium confusum* Duv., the Mediterranean flour moth, *Ephestia kuehniella* and the Indian meal moth, *Plodia interpunctella* Hbn. These insects are annually troublesome and injurious pests of stored products.

TABULAR SUMMARY

It is felt that the average reader of the foregoing summary dealing with the more important economic insect pests in the Dominion during 1930, would more readily secure a concrete impression of the facts included therein if the information were arranged in tabular form by provinces, the common names of the insects being grouped in one of three sections according to whether the species increased or decreased in abundance or destructiveness, or remained unchanged as compared with 1929.

This arrangement is merely tentative and makes no attempt to indicate the comparative importance as pests of the various species, the intention being only to reveal more plainly the trend in numerical abundance or economic importance of individual species, or groups of species, in the various provinces of the Dominion, as reported by entomological workers generally.

Tables showing the reported trend in abundance or destructiveness of various Species of Insect Pests in 1930 as Compared with 1929.

(For more complete details see preceding text)

NOVA SCOTIA

Increase	No change from 1929	Decrease
Alder flea beetle	Apple sucker	Apple aphid
Apple leaf hopper	Beech scale	Apple & thorn skeletonizer
Apple maggot	Black-headed tip moth	Carrot rust fly
Apple seed chalcid	Colorado potato beetle	Cigar case-bearer
Birch leaf skeletonizer	Corn ear worm	European red mite
Clover mite	Cucumber beetle	Eye-spotted budmoth
Codling moth	Household & Stored product insects	Fall cankerworm
Cutworms	Imported cabbage worm	Larch case-bearer
Eastern tent caterpillar	Imported currant worm	Oyster shell scale
European corn borer (light infest.–slight increase)	Larch sawfly	
Fall webworm	Mosquitoes	
Gray-banded leaf roller (Berwick dist.)	Oblique-banded, white triangle and dusky leaf rollers	
Green fruit worms	Onion and cabbage maggot	
Hemlock looper	Plum curculio	
Pear slug	Potato flea beetle	
Satin moth*	Rosy apple aphid	
Spruce bark beetles	White-marked and rusty tussock moths	
Tarnished plant bug	Zebra caterpillar	
Turnip aphid		

NEW BRUNSWICK

Apple aphid	Apple maggot	Birch sawfly leaf miner
Apple leaf hoppers	Apple & thorn skeletonizer	Carrot rust fly
Apple leaf sewer	Beech scale	European red mite

NEW BRUNSWICK.—*Continued*

Increase	No change from 1929	Decrease
Birch leaf skeletonizer	Cigar case-bearer	Eye-spotted budmoth (in St. John valley)
Cabbage & horse radish flea beetles	Colorado potato beetle	Fall cankerworm
Codling moth	Corn ear worm	Greasy cutworm
Cucumber beetle	Cutworms	Imported currant worm
Eastern tent caterpillar	European corn borer (infestation light)	Larch case-bearer
Fall webworm	Household & Stored product insects	Larch sawfly
Green fruit worms	Imported cabbage worm	Lesser apple worm
Pear leaf blister mite	Mosquitoes	Oyster shell scale
Pear slug	Onion & cabbage maggots	White-marked tussock
Potato stem borer	Plum curculio	
Satin moth *	Potato flea beetle	
Strawberry weevil	Spruce & pine aphids	
Tarnished plant bug	Zebra caterpillar	
Ugly nest caterpillar		

* Recorded for the first time in Eastern Canada.

QUEBEC

Birch leaf skeletonizer	Apple curculio	Apple aphid
Eastern tent caterpillar	Apple maggot	Hemlock looper
Fall webworm	Carpenter worm	Maple leaf cutter
Grasshoppers	Codling moth	Pitch twig moth (Kippewa district)
Larch sawfly	Colorado potato beetle	Tarnished plant bug
Monochamus beetles (Kippewa district)	Cucumber beetle	
Mosquitoes	Cutworms	
Pear Slug	European birch leaf miner	
Poplar borer	Eye-spotted budmoth	
Raspberry cane borer	Household & Stored product insects	
White grubs	Horse radish flea beetle	
	Imported cabbage worm	
	Jackpine sawfly	
	Larch case-bearer	
	Onion & cabbage maggots	
	Pea aphid	
	Plum curculio	
	Yellow-headed spruce sawfly (Gaspe)	
	Zebra caterpillar	

ONTARIO

Apple leaf hoppers	Apple & thorn skeletonizer	Apple aphid
Birch leaf skeletonizer (Muskoka)	Colorado potato beetle	Apple maggot
Codling moth	Corn earworm	Black cherry aphid
Cotton moth (adults)	Cucumber beetle	Carrot rust fly
Dark-sided cutworm (S. W.)	Eye-spotted budmoth	Cigar case-bearer
Eastern tent caterpillar	Gladioli thrips	European corn borer
Fall webworm	Household & Stored product insects	European red mite
		Fruit tree leaf roller

ONTARIO.—*Continued*

Increase	No change from 1929	Decrease
Grape leaf hoppers	Horse-radish flea beetle	Lilac leaf miner
Grasshoppers	Imported cabbage worm	Maple leaf cutter
Hop flea beetles	Larch sawfly	Onion and cabbage maggots
Jackpine sawflies (Bisco)	Mexican bean beetle	Oriental fruit moth
Larch case-bearer	Mosquitoes	Other leaf rollers
Pale striped flea beetle	Onion thrips	Pear psylla
Potato flea beetle	Pea aphid	Plum curculio
Raspberry cane borer	Red spider mite	Rosy apple aphid
Raspberry fruit worm	Spruce budworm	Spruce leaf miner (local)
Rose chafer	Spruce sawfly	Tarnished plant bug
San Jose scale	Turnip aphid	
Seed corn maggot	Walnut caterpillar	
Silver leaf mite	White-marked tussock moth	
Smartweed flea beetle	Yellow headed spruce sawfly (local)	
Spinach leaf miner	Zebra caterpillar	
Ticks (Middx. Co.)		
Tobacco stalk borers		
White grubs (E.)		
Wireworms (S. W.)		

MANITOBA

Aspen poplar and willow leaf beetles	Bot flies	Bertha armyworm
Beet webworm (weeds)	Colorado potato beetle	Hessian fly (scarce)
Birch leaf skeletonizer	Currant aphid	Lime tree looper
Boxelder aphid	English grain aphid	Mosquitoes
Boxelder leaf roller	Household & stored product insects	
Grasshoppers	Onion & cabbage maggots	
Green bug (W.)	Spruce sawfly	
Horn fly (E.)	Tabanid flies	
Imported cabbage worm	Western blister beetle	
Ox warble fly (E.)	Wireworms	
Pine needle scale	Yellow-headed spruce sawfly	
Red backed cutworm (W.)		
Red spider mite		
Rose curculio		
Seed corn maggot		
Stable fly		
Ugly nest caterpillar		
Wheat stem sawfly (W.)		

SASKATCHEWAN

Ants	Black willow aphid	Bertha armyworm
Beet webworm (weeds & vegetables	Colorado potato beetle	Hessian fly (scarce)
Birch leaf skeletonizer	Currant aphid	Imported currant worm
Black files (Sask. R.)	English grain aphid	Larch sawfly
Boxelder aphid	Forest tent caterpillar (N.W.)	Mosquitoes
Boxelder leaf roller	Household insects	
Cabbage maggot	Onion maggot	
Currant fruit fly	Western blister beetle	
	Wireworms	

SASKATCHEWAN.—*Continued*

Increase	No change from 1929	Decrease
Diamond back moth	Yellow headed spruce sawfly	
Elm aphid		
Grasshoppers		
Green bug (E.)		
Imported cabbage worm		
Pale western cutworm		
Pine needle scale		
Poplar leaf-folding sawfly		
Red backed cutworm		
Red spider mite		
Spider mite (*T. ununguis*)		
Spruce & larch aphids		
Spruce sawfly (N.)		
Stored product insects		
Wheat stem sawfly		
White grubs (N. E.)		
Wireworms (gardens)		

ALBERTA

Ants	Black willow aphid	Bertha armyworm
Beet webworm (weeds)	Cabbage maggot	Currant spanworm
Currant fruit fly	Colorado potato beetle	Mosquitoes
Diamond back moth	Household & Stored product insects	Wireworms
Elm aphid		
False chinch bug (not important	Onion & cabbage maggots	
Imported cabbage worm	Sugar beet root aphid	
Pale western cutworm (E)	Western blister beetle	
Poplar leaf-folding sawfly		
Red backed cutworm		
Red spider mite		
Steam maggots (*H. cerealis*)		
Wheat stem sawfly		

BRITISH COLUMBIA

Ants	Apple aphid	Bertha armyworm
Aphids (except woolly apple aphid)	Apple curculio	Codling moth
Black-headed tip moth	Black flies	Currant fruit fly
Cabbage flea beetle	Bot flies	Cutworms
Diamond back moth	Carpenter worm	European earwig
European lecanium scale	Cigar case bearer	Fall webworm (coastal)
False chinch bug	Clover mite	Hemlock looper
Grasshoppers	Colorado potato beetle (S. E. corner)	Imported cabbage worm
Hemlock bark maggot	Household & Stored product insects	Imported currant worm
Onion & Cabbage maggot	Imported currant borer	Lesser apple worm
Pear leaf blister mite	Lilac leaf miner	Oyster shell scale
Pine bark beetles	Mosquitoes	Peach twig borer
Rose sawflies	Satin moth	Pear slug
Spinach leaf miner (V. I.)	Spruce budworm (Cariboo)	Spruce budworm (V. I.)
Ticks	Sugar beet root sphinx	Wasps
Tussock moth (*H. pseudotsugata* McD.)	Tabanid flies	Woolly apple aphid
Wireworms	Tarnished plant bug	
	Tent caterpillars	

THE FIRE BLIGHT OF APPLES ON THE SOUTH SHORE OF THE LOWER ST. LAWRENCE

By C. Perrault, Laboratory of Plant Pathology, Ste. Anne de la Pocatiere.

The bacterial blight caused by *Bacillus amylovorus* (Burr.) Trev., made its appearance in a very severe form last year, in some of the orchards east of Quebec, on the south shore of the St. Lawrence. Thanks to the diligence of the instructors of the Provincial Department of Agriculture, to the co-operation of the producers and to the radical methods employed, the disease was quickly checked in its expansion.

During the first weeks of early summer this disease spread in the region between Levis and River du Loup, and threatened all the orchards with either complete destruction or of considerable damage. Without the prompt and effective interference mentioned its havoc would have been disastrous, because of the complete failure of the owners to follow necessary orchard practices.

No doubt, a few, but a very few, amongst them used certain methods of protection and control, whenever time permitted, but the value of their efforts was lessened due to the carelessness of their neighbors?

The awakening came last spring when the blight was discovered in one of the most important orchards of St. Roch des Aulnaies, by Mr. G. Gauthier, whose duties are to supervise the spraying of fruit trees in that region. The disease had already done considerable damage in this orchard, and several trees had to be uprooted while others were subjected to a severe pruning.

A campaign of eradication and of education was then undertaken in the counties of Kamouraska, l'Islet, Montmagny and Bellechasse, or wherever the disease had made its appearance. At St. Vallier, St. Roch, St. Pamphile, and St. Michel, several trees were cut down or burnt. At St. Vallier 25 trees were disposed of in a single orchard.

These orchards were, without doubt, the source of such serious infection that their destruction was imperative, especially under the prevailing conditions. Most of these trees were very old and their branches were intermingled, therefore they bore all the conditions favoring the development of the disease.

Out of a total of 112 orchards, each containing 50 or more apple trees, the fire blight was present in one third of them. The same disease was also found on pear trees, mountain ash and hawthorn.

A table is submitted herewith showing the number of orchards affected in each parish with the percentage of infection where the blight was found. An infection was considered serious where the trees had to be cut down or burnt. The figures are the result of the investigations made by instructors and pathologists of the Department of Agriculture of the province.

COUNTIES	PARISHES	Number of orchards where the disease was found	DEGREE OF INFECTION		
			Slight	Average	Severe
Kamouraska	St. Alexandre	3		X	
"	St. Pascal	1	X		
"	St. Pacome	1	X		
"	St. Anne	1	X		
L'Islet	St. Roch	40			X
"	St. Eugene	1	X		
"	St. Pamphile	6			X
Montmagny	Cap St. Ignace	1	X		
"	St. Pierre	5	X		
"	Montmagny	1			X
Bellechasse	St. Valier	12			X
"	St. Michel	3			X

The foregoing denotes the urgent necessity for the thorough cleaning made in the orchards of that region, and how imperative it was for each owner to follow explicitly the methods of protection prescribed by the pathologists if he wished to obtain any revenue from his orchard.

A very short period would have sufficed to obliterate completely a small but profitable industry, which, in times such as the present, brings in an appreciable revenue to the careful and wide awake farmer.

THE PINE SHOOT MOTH

Rhyacionia (Evetria) frustrana Comstock, In the Province of Quebec.

By Lionel Daviault, Entomological Branch, Ottawa, Ont.

The Pine Shoot Moth (*Rhyacionia frustrana*), for whose indentification we are indebted to Dr. MacDunnough, is a microlepidopteran which is fairly well known throughout the eastern section of the North American continent. A variety of the same species exists in the southwestern section of the United States known as *R. bushnelli* Busk which has caused considerable havoc in the nurseries of Nebraska, and this has been studied at length by Graham & Baumhofer (1927).

Several observations made in the Province of Quebec during the course of the summer of 1931 denote that the habits of this species present certain differences, and even though our observations were rather limited, we believe that their publication will be useful.

The ravages caused by this microlepidopteran were first noted in the plantation of the Ministry of Lands and Forests, situated in the concession of St. Philomene at Berthierville, Q.

The oldest part of this plantation consists particularly of red pine (*Pinus resinosa*) and a few scattered scotch pines (*Pinus sylvestris*), and white pine (*P. strobus*), as well as a mixture of mountain pine (*P. montana*), while the section most recently planted contains a mixture of the above named species with a few Norway spruce (*Picea excelsa*).

Up to the present, only this latter section of the plantation has been attacked, and it is quite possible that it will not spread beyond that, because according to Graham & Baumhofer (1927), the largest and oldest trees are generally attacked. The larger percentage of infection is to be found amongst the red and the scotch pines, but the other species have not entirely escaped.

Appearance of the injury

During the early spring there is very little difference between the healthy and the infected shoots, but later, when they are in bloom, they wither and the needles become discolored and dry up, and while in this condition they are often damaged by the wind which makes them hang wretchedly. Another feature is that immediately the caterpillar has done its mischief and leaves, the shoots are attacked by the wood weevil.

The following year there develops around the dead shoot several lateral buds which produce as many new shoots, and when the tree has been seriously attacked its appearance is singularly changed.

Again, accordingly to Graham & Baumhofer, in all serious cases up to 70% of the lateral shoots may be attacked. It is clear, therefore, that if a similar infected condition prevails for several years the growth of the tree will be affected materially and it may die.

Biology

The Pine Shoot Moth has two generations a year in all parts of the United States, but according to our observations only one generation occurs in the Province of Quebec.

The insect hibernates as a pupa in a small silky cocoon stuck to the tree trunk or among the refuse on the ground. The adults are the first to appear during the first warm spring days and they can be seen flying around towards sun down. They fly awkwardly and low, and during the day time they are at rest in between the needles where they are barely visible.

The pairing and egg laying are done at night. The eggs are oval in form and about ½ mm. in diameter, pale yellow, and are generally laid singly or in groups of not more than two or three on either the needles or the buds.

The length of time required for egg development varies according to the temperature, but the average is from 10 to 15 days.

The newly born caterpillar comes out of the egg through an irregular opening and immediately proceeds to seek food, although it can easily live for a whole day without any nourishment. It invariably goes for the new shoots and the base of a needle or for a bud where it proceeds to weave a protective web which it coats with rosin; then it begins to eat the exterior surface of the stem which lies immediately under its web, where it perforates the base of the needle, and finally introduces itself into the shoot. The balance of its development is done within the interior of the shoot and during all of this period it maintains an opening clear so that it can communicate with the outside.

At the time of pupation the caterpillar leaves its refuge to weave a web on the stem but often this is done in the debris lying on the ground and after a few days rest the transformation is complete.

Parasites

The percentage of parasitism was around 20 in 1931, and we secured in all, three different hymenopterous species which have not as yet been identified.

Graham & Baumhofer (1927), list a collection of 16 different species found in Nebraska: 1 Bethylid, 6 Ichneumonids, 3 Braconids, 5 Chalcidids and 1 Tachinid.

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A FEW REMARKS REGARDING THE ERADICATION OF THE DISEASE KNOWN AS WILD FIRE IN THE TOBACCO PLANTATIONS IN THE YAMASKA VALLEY

By R. Bordeleau, director Dominion Experimental Farm, Farnham, Que.

1.—General considerations regarding the organism which brings about the disease.

(*a*) Organism which brings about the disease.

The Wild Fire disease of the tobacco plant is caused by *Bacterium tabacum* W. & F.

(*b*) Symptoms.

This organism produces spots on the tobacco leaves commencing with the first stage of vegetation and up to maturity.

With the very young plants the organism is the cause of a wet rot characterized by lesions on the leaves, either marginal or terminal, which make rapid headway and can destroy the plants completely in the hot beds, and even though the plant should survive and be transplanted to the field it is very doubtful whether it can reach maturity.

In the field, the syptoms of the disease are as follows. The blemishes appearing on the leaves are circular in form and of a green color much lighter than that of the balance of the leaf. Quite at an early stage a brown speck appears in the blemish which is surrounded by a pale green circle quite in contrast with the deep green color of the leaf. Whenever the organism of the disease is favored by optimum conditions of temperature and humidity the blemishes increase rapidly until the plant is ruined and is, therefore, a complete loss to the planter.

However, if the disease is kept within bounds by unfavorable conditions of temperature and humidity, then the damage may be slight.

(*c*) Life cycle.

It may be possible that the seed is a means of inoculation in the hot beds in the spring time and this theory is still under discussion at the present time. But, most assuredly, the organism hibernates in the waste of the tobacco remaining on the fields, and in the curing houses, hence the wind, as well as the necessary working tools which are kept in these houses, can easily transmit the disease, especially when the windows of the hot beds are removed to allow the plants to become hardier just before being transplanted to the field. Consequently, the infection may take place in the seed bed and the results can readily be seen in the field. In the fall the tobacco is put into the curing barns and infected

leaves left on the field become an excellent place for the disease to hibernate which will once more infest the tobacco the following year either in the field or in the hot beds.

2.—Progress of the disease since its discovery.

The Wild Fire, unknown in Canada prior to 1925, was discovered by Mr. J. E. Montreuil, Director of the Experimental Station at Farnham, in five tobacco fields at St. Cesaire and in another at l'Ange Gardien, County of Rouville. In 1926, the disease was rediscovered in only three of the fields. In 1927, seven fields were infected. In 1928 the disease caused considerable havoc and damaged plantations up to 25% and 50%. The year 1929 showed material improvement and very few serious cases were noted, thanks to the precautions taken to overcome the disease, and to the favorable conditions of temperature and humidity. In 1930 hardly any indication of the disease was found, while in 1931 it had been entirely eliminated.

3.—Methods of eradication employed.

In order that you may clearly understand this part of my address, I believe it is well to give you the following information.

That section of the Yamaska Valley where the cultivation of tobacco is the main crop, comprises an area of about 250 square miles, and the area planted in tobacco alone covers about 1500 acres divided amongst five or six hundred planters. Three-fourths of these planters are members of the Cooperative Society of the Tobacco Producers of the Yamaska Valley, with headquarters at St. Cesaire.

When the disease made its appearance in 1925, our Experimental Station, whose principal occupation is to experiment with tobacco, made an effort to do all in its power to eradicate the disease, and the following advice was given to all concerned:

1. To avoid doing any work within the infected fields either directly after the morning dew or after rain.

3. That the planters whose fields were free of the disease avoid visiting infected fields.

2. That within such plantations where only a few plants were affected these be uprooted and burnt.

4. To plow the fields immediately after the harvest of the tobacco in order to bury the remaining waste and thereby prevent the budding which develops at the crown after the harvest.

5. That the waste remaining in the curing houses after the stripping of the leaves be burnt up.

During the course of this season a thorough search was made to discover all the foci of infection. After having located a field where the infection was apparent, the party in charge of this work proceeded to disinfect his hands and

clothing, with a sprayer, such as is commonly used to vaporize oils against flies on animals, before entering another plantation, using a solution containing 40% formalin. Samples of infected leaves, previously disinfected, were shown to the planters in order that they become familiar with the disease.

During the course of the winter, meetings were held in the principal centres of production when the organism of the disease was fully explained together with the most favorable conditions for its development and the means of its eradication. Furthermore, we conducted an intensive campaign towards the disinfection of the hot beds with formalin, because these are an important centre of infection and often the symptoms of the disease are hard to discover.

In the spring of 1926, our station disinfected gratuitously the hot beds where the disease existed the year before. There were five such locations.

The disinfection proceeded in the following manner:

After the beds were free of frost and sufficiently dry to allow them to be properly prepared, they were levelled in order that the disinfecting solution should penetrate evenly and we proceeded with the application of formalin.

We made use of the commercial formalin which contains 40% formaldehyde, on the base of one (1) gallon to 50 gallons of water, then the beds were sprinkled at the rate of half a gallon to one square foot of the bed. A hot bed 5 by 12 feet, (60 square feet), calls for 30 gallons of solution. Since this quantity is much too great to be absorbed rapidly by the soil the sprinkling is regulated so that the solution of the disinfectant can have ample time to penetrate the whole depth of the soil without much loss from the surface. Immediately after the sprinkling has taken place, and in order to prevent the too rapid escape of the formalin vapors, the bed must be covered with paper (old newspapers will do) and the frames must be closed to prevent evaporation. After 24 hours the coverings are removed and the hot bed is thoroughly aired. The seeding must not take place earlier than eight (8) days afterwards, in order to make sure that the formalin vapors have entirely disappeared, otherwise the germination would be hampered. Both the frames and the windows of the hot beds must also be disinfected.

Furthermore, we strongly advise removing the hot beds away from the curing barns which might be a means of contamination through the waste contained therein as the disease can be carried by the wind. We also advise destroying the old soil and employing new one.

In 1927, the disease made very little progress and the over confident planters thought that the danger was passed. But the season of 1928 was very favorable to the development of the disease and it made rapid headway.

The following year a successful campaign of eradication was organized by the Cooperative Society of the Planters of the Yamaska Valley, jointly with our station. After the stripping of the 1928 harvest, two men paid by the society went to all the planters and disinfected the dry barns with a formalin solution of 1 to 50. This disinfecting solution was vaporized with spraying pumps installed on tanks of 40 gallon capacity. A complete disinfection was

made of the dry barns, the laths, the machinery and tools utilized in tobacco production, and the following spring the formalin solution necessary to disinfect the hot beds was furnished free of charge to the planters by the society.

Meanwhile the Farnham Experimental Station did the same work for the non-members of the cooperative society upon the payment of the cost of the formalin.

Thanks to these precautions there were very few cases the following year. Furthermore, we took 1000 tobacco plants from disinfected hot beds of a plantation which formerly had been the seat of infection. These were planted in an isolated section of our experimental farm, where Wild Fire had not previously occurred, and produced a perfectly sound harvest.

The planters also took the same precautions and while the season was favorable to the development of the disease only a few cases were reported.

The disinfection of the hot beds, and the dry houses, and the machinery, and the tools, and preventive methods such as pulling out infected plants the moment the disease appears, and avoiding working in the fields when the plants are humid, as well as plowing immediately after the harvest, have been the best means to keep the disease in check.

PRESENT STATUS OF THE WHITE PINE BLISTER RUST IN THE PROVINCE OF QUEBEC

By René Pomerleau, Forest tree diseases Research laboratory, Berthierville, Que.

Introduction

The White Pine Blister Rust has, for some time, greatly interested Foresters and Plant pathologists, still nothing of a serious nature had been attempted to stay its havoc; we knew very little of the extent of its ravages and did not realize how serious an enemy it was to the propagation of this species of trees.

However, the question is once more to the fore, and last year, after having noticed the extended nature of the infection in the nurseries around Berthier, we were assigned, by the Chief of the Provincial Forestry Service, at Quebec, Mr. G. C. Piché, to take effective means to cope with this destructive plague of our forests. But in order to bring satisfactory results to such an undertaking, we had, right from the start to gather all the facts, heretofore published, relating to this disease, then determine, within reasonable exactness the extent and the importance of the White Pine in our Province, as well as the distribution of the White Pine Blister Rust in the various fields.

The object of our search was for the purpose of showing how detrimental such a disease was to our province, and how imperative it was to take the necessary measures to prevent it from making further headway where it is already at work, as well as to prevent its further expansion.

We now present a summary of the facts that we have gathered in the course of the last season including what we have ascertained through our bibliographic survey.

History

The White Pine Blister Rust has only recently invaded this country, but it has been in evidence both in Europe and in the United States where it has been recognized as a serious disease.

The organism which is the cause of this disease (*Cronartium Ribicola* Fisher) existed in the past in an endemic state on cembra pine (*Pinus cembra*) in Europe, but after the advent of White Pine (*Pinus strobus*) in Europe in 1705, the organism in question passed onto this latter species and made alarming progress. We take it that this occured in the neighbourhood of the Oural before it became general in all sections of Europe.

The organism of the White Pine Blister Rust was first discovered on White Pine as well as on Red Currant and Gooseberry bushes (*Ribes spp.*) by Dietrich in the Baltic provinces, in Russia, in 1854. Later it was successively found in Finland (Hesinger 1861), in oriental Prussia (1865), in Sweden (Erikson 1869), in Denmark (Rostrup 1883), and later on in all northern parts of Europe.

It made its appearance in North America, where the White Pine originated, in 1906 only, at Geneva N. Y., but indications of the disease found elsewhere demonstrated that it existed in 1898. No doubt, the introduction of the white pine blister rust in the United States occurred when importations were made from the European nurseries at the time when attemps were made to re-stock with white pine large sections denuded of trees. Since then the Blister Rust has gained footing in all the New England states as well as those of the lake region.

The Province of Quebec was free of this pest for a long time, and this caused us to believe that it could not gain any footing here, due to climatic and other unfavorable conditions. But contrary to expectations a few scattered trees giving evidence of this disease were found in Ontario in 1914 and in Quebec in 1916.

It was first found in the Province of Quebec by Fraser on gooseberry bushes at St. Anne de Bellevue and at Oka in 1916, and later on, on white pines in the seigniory Perthuis in Portneuf county, in 1918. Since then it has made itself apparent in various sections from year to year.

Importance of White Pine.

From a practical standpoint, the stands of white pine in the Province of Quebec are limited to the Valleys of the St. Lawrence, the Outaouais and its confluents, while it is found in small quantities up to Abitibi lake, and towards

the north shore in the neighbourhood of Seven Islands. At this date there is still some growths in the St. Maurice valley, the Outaouais, the Gatineau, and in certain regions of the south shore of the St. Lawrence from the American frontier up to Dorchester county.

We quote what Mr. G. C. Piché, Chief of the Provincial Forestry Service, wrote in this connection in 1917:

"Setting aside the sections where the white pine is scarce, we can estimate that this tree is still an important factor over an area of about 37,000 square miles, in the Province of Quebec. And taking as a basis the explorers' reports with the measurements taken during their explorations, we have reason to believe that the total volume of white Pine in this province amounts to about 25 billions F. B. M., which, at $4.00 per M. F. would give a value of $100,000,000 for this species of wood just as it stands in the forest.

"The yearly output of white pine is about 250 million feet B.M., of which 80% comes from Crown Lands licensed to dealers, and the balance from private lands. The Province actually collects an annual revenue of about $450,000, or a quarter of the total revenue from woods operations. Since white pine has an average value of $22.34 per M feet in Quebec, it follows that each year this species contributes a sum of over $5,000,000 to the commerce of our province".

Distribution of White Pine in the Province of Quebec.

Since that time, no doubt, a considerable change has occurred through the extensive exploitation of the forests and particularly by forest fires both of

FIG. 1.—White pine distribution in Quebec.

which have reduced the extent and the density of this species within the limits of the Crown Lands.

During the course of last years' survey, 107,604 acres of privately owned forests, of which 70,577 contained more than 40% white pine, were visited in the inhabited sections and privately owned lands in the counties of Maskinongé, Berthier, Joliette, Montcalm, L'Assomption, Two Mountains, Argenteuil and Richelieu. We may consider the surveyed portion as being about 1/6th, of the area of privately owned lands of the Province of Quebec. Consequently there remains over 650,000 acres of privately owned forests where white pine predominates.

IMPORTANCE AND DISTRIBUTION OF THE WHITE PINE BLISTER RUST IN THE PROVINCE OF QUEBEC

As we have already stated, the official records showing the presence of this disease in the Province of Quebec go back to 1916 and 1918. Today, it is scattered in some proportion almost every where, even outside of the white pine area—St. Anne de la Pocatière, Rivière du Loup etc.—and we can say without exaggeration that it is possible to find this rust in most of the inhabited sections of the province. By examining the map (fig. 2) of the province it will be easy to perceive that this disease is nearly equally distributed throughout the valleys of the Outaouais and the St. Lawrence rivers.

We noted, during last year's excursions, that the presence of the disease had spread more or less on the pine trees and the Ribes at Berthierville and its neighbourhood, at Oka, Hudson, Lac Beauport, St. Anne de Beaupré, Lotbinière, St. Jovite, l'Annonciation, etc. It was particularly at St. Jovite that the ravages were most prominent.

In the plantation of the International Paper Company, Ltd., located along the shores of the Cachee river, county Terrebonne, over 50% of the pines planted are seriously attacked, while the balance is due for an early demise because of the almost incredible aboundance of Ribes here. In this same region other plantations were also affected but to a much lesser extent, namely about 10%. In 1930, in the plantation of the Department of Lands and Forests, at Lachute, we found young trees already infected.

The foregoing examples regarding the existence of the White Pine Blister Rust will suffice to demonstrate that this disease is of grave concern to this province. However, its invasion is still recent as our observations indicate that none of the cankers were more than 6 or 7 years old, hence the infection most likely commenced in 1924 or 1925 . There may be cases where the date of infection is more remote but surely the number is insignificant.

Since the rust is in evidence in all in habited sections, we wonder if it does not exist also in leased forest or other limits. This problem has not been studied in its entirety, still we found that 45% of the young pines in the forest of the

Trembling Mountain were seriously affected, but on the other hand, at River a l'Aigle, in the Gatineau district where white pine is to be found in reasonably

FIG. 2.—Distribution of the White Pine Blister Rust in Quebec. Heavy line shows area surveyed in 1931. White pine infections are indicated by large dots; Ribes infections by small dots.

large quantities, we failed to find a single sign of the disease either on the pines or on the leaves of the Ribes.

Consequently we are not in a position to arrive at any definite conclusion at this time, as the Crown Timber Limits should be thoroughly examined. And we wish to point out that even if the disease is not in evidence in certain regions at the moment, it will likely attack them sooner or later.

Distribution and frequency of the Ribes.

The species of Ribes, whether wild or cultivated are well spread throughout the province, but the wild species are particularly in evidence where the land is wet and abounds with tree growth.

Taking as a basis our observations from the work already accomplished, there would be from 5 to 15 bushes of Ribes to the acre. In the River Cachee plantations, where an attempt was made to eradicate this species, there were 600 to 800 bushes to the acre. This abundance of Ribes is most extraordinary, yet it can be readily explained since we are familiar with the germination of the seed of this particular shrub.

In this connection, we quote what Mr. A. E. Fivaz says in a recent publication:

"Experiments and observations reported in this bulletin indicate that viable seed of some species of currants and gooseberries, particularly of *Ribes rotundifolium* accumulate on the floor of white pine areas during periods favorable to the bearing of fruit by plants of these species, that these seeds may remain dormant on the forest floor for protracted periods; and that they germinate soon after the occurence of forest-floor disturbances such as are caused by ground fires, logging operations, windfalls and road building. Apparently, such disturbances of the forest floor are essential for the general germination of these naturally stored Ribes seeds. Those seeds may germinate under a heavy forest canopy if the forest floor is disturbed down to the mineral soil."

The preceding cases, which are confirmed by the foregoing quotation, clearly demonstrate that it is dangerous to reforest old burnt-over lands with white pine, before ascertaining that the Ribes are limited in quantity.

The species of Ribes most in evidence is, without any doubt, *Ribes glandulosum*, on which blister rust is almost invariably found. Then comes *R. cynosbati*, which is almost as prolific, while *R. triste* var. *albinervum* is also quite in evidence and almost always affected with the blister rust. *R. lacustre* is somewhat less in evidence but it seems to be subseptible to the blister rust as well. *R. americanum*, which is preeminent along rivers and streams, especially in the neighbourhood of the St. Lawrence river, is also affected similarly to the preceeding species. The latter is sometimes cultivated as a fruit bearing shrub, while the other Ribes such as *R. hirtellum* and *R. oxyacanthoides* are rarely found in these regions.

Ribes nigrum, which is generally under cultivation amongst the farmers and gardeners, is an important factor in the distribution of the blister rust.

As a matter of fact most of the leaves of this species are covered with spores during the month of August. *R. grossularia* and *vulgare*, could be cultivated to better advantage than the foregoing, because they are less susceptible to the attack by the blister rust, and while we find many gardens where *R. nigrum* is highly infected, it is difficult to find even a trace of any infection on *R. grossularia*, and still less on *R. vulgare*.

PRELIMINARY WORK COMPLETED IN 1931

The program for the preliminary work which we were called upon to accomplish last year comprised the following two principal objects.

1. The inspection of the white pine nurseries in certain counties in the neighbourhood of Berthier, and the education of the owners of white pine stands.

2. The establishment of a protective zone around the Provincial nursery at Berthierville.

Inspection

This first part of our program was organized for the purpose of enabling us to gather all particulars which would serve as a starting point towards taking the necessary steps to combat the disease. But in order to succeed in this instance and obtain really valuable figures it became necessary to go far afield, and then localize, on maps, all the forest nurseries containing white pine. It is due to this survey that we were able to determine the extent and the sanitary conditions of the White Pine nurseries, within the districts visited by us; the presence and the intensity of the Blister Rust in these nurseries; the distribution of the divers species of the Ribes and, at the same time, the possibility of coping with the disease. Furthermore, a campaign of education was started amongst the farmers and others interested.

Our undertaking was carried on during the months of August, September and October, in the counties of Berthier, Joliette, Richelieu, Maskinongé, Montcalm, L'Assomption, Two Mountains and Argenteuil. All the Inspectors, appointed to assist us, were graduates of the School of Forestry Guards of Berthierville, hence they were especially trained for this kind of work.

The information gathered in the regions inspected by us is contained in Tables 1 & 2. Table 1 indicates the number of acres covered by White Pine forest in each county, with the number of lots on which the stands exist; an approximate evaluation of M. feet, BM contained; the percentage of healthy stands an average of the age of the trees, the percentage of the Blister Rust and the age of the cankers.

INSPECTION OF THE WHITE PINE BLISTER RUST 1931

County	Number of trees	Number of lots visited	Feet	% of purity	Av. age of the pines	% of rust	Av. age of cankers	Species of Ribes	Frequence
Berthier	11,799	6,374	81,692,000	41.9	50	3.4	5.0	Gland. Cy. Am. Triste, Lac. Nig.	Very frequent
Maskinongé	16,047	3,639	71,400,000	22.6	44	3.3	4.7	Gland. Cy. Lac. Am. Nig.	A great deal.
L'Assomption	8,444	3,136	27,651,000	53.5	63	1.6	5.9	Gland. Nig.	Little.
Argenteuil	492	2,955	642,000	65.0	54	1.1	3.8	.....	.....
Montcalm	6,680	2,437	15,420,000	46.2	55	3.2	5.0	Gland	Little.
Richelieu	61,616	2,632	409,686,900	65.4	40	1.3	3.9	Am. Gland. Lac. Triste.	Little.
D.-Montagnes	1,545	1,280	2,176,000	52.6	50	2.6	3.2	Vul. Cros. Nig. Gland.	Very frequent
Joliette	981	4,014	11,090,000	45.	41	2.5	6.6	Gland. Cy. Nig. Triste.	Little.
Totals	107,604	26,467	619,667,900	.....	.....	.....	.....	.....	.....

CLASSIFICATION OF WHITE PINE STANDS

County	Number of Stands	Number of acres	Stands to be Protected				Stands to be neglected	
			Immediately		Later		Number	Acres
			Number	Acres	Number	Acres		
Argenteuil	37	492	36	490	1	2	.....	.....
Maskinongé	48	16,047	8	2,996	7	1,831	33	11,220
Richelieu	28	61,616	21	48,950	.....	.....	7	14,666
Montcalm	12	6,680	8	4,680	3	1,985	1	15
Deux-Montagnes	12	1,545	11	1,530	1	15	.....	.....
L'Assomption	16	8,844	13	5,954	3	2,490	.....	.....
Joliette	73	981	30	564	23	266	20	151
Berthier	73	11,799	44	7,413	11	1,452	18	2,934
Totals	299	107,604	171	70,577	49	8,041	79	28,986

Table 2 is a summary of each separate nursery, classed according to their importance. This classification is based upon the area of the nursery, the age

and the percentage of healthy trees, the nature and topography of the soil, the percentage of Blister Rust, age of infection, the species of Ribes and their occurrence.

These findings enabled us to determine the relative value of each nursery and, to illustrate further we have thought advisable to divide them into the following three categories.

1. Those which should be protected immediately must contain at least 40% White pine affected with the blister rust, and their location sufficiently advantageous to the proper development of a Pine forest. That is, if a stand is located on a rocky hill side, for example, it can never reach a reasonable growth, hence its protection would not be beneficial from the standpoint of forestry.

2. Those which do not call for immediate protection. The forests having less than 40% but more than 20% white pine and whose ecological location is advantageous to attain a fair growth, are classed in this category.

3. All others, not in either of the above classes and whose protection cannot be recommended on account of economical factors.

The following is a summary of our observations for each county.

BERTHIER

This county is second in rank, Richelieu being first, in as far as the density of White Pine is concerned. This county, the largest number of White Pine stands occur on the border of the St. Lawrence river. In Lavaltrie, Lanoraie and Berthierville there are a number of nurseries entirely free of disease, while the nurseries throughout the balance of the county are more or less important, they are scattered and the density of White Pine is lower.

The Blister Rust, is to be found in all the nurseries, without hardly any exception. A certain number of trees are already attacked. In general the infections do not appear to be very old and the cankers are not over 5 or 6 years old. Which means that in most cases the infection was not in evidence prior to 1925 or 1926.

The Ribes are quite prominent in this county and the following species were recognized: *R. gladulosum, triste* var. *albinernum, cynosbati, lacustre, americanum, vulgare, nigrum & grossularia.* The *R. glandulosum* is the most abundant, and *R. americanum* exists in very dense and compact clusters in the lower part of the county, along the rivers and the St. Lawrence.

Since we endeavored to eradicate the disease at Berthierville, we are in a position to give some figures regarding the extent of the Ribes in this region, where a total of 8860 bushes of Ribes were up-rooted in 2136.65 acres of forest lands, which gives an average 6.7 buches per acre and 4.1% per acre in partly wooded and cultivated areas.

The eradication of the Ribes is of immediate importance if the majority of the stands in Berthier county are to be given the necessary protection. Table 2

shows that there are 73 pine groves in this county which cover an area of 11,799 acres. Of this number, 44, with an area of 7,413 acres, belong to the first category consequently they should be protected at once. Of the remaining 29, there are 11 whose protection could be put off until later, because the percentage of white pine is less than 40%, hence less valuable than the former, and 18 which can be completely overlooked because they do not contain sufficient white pine, or because of their unfavorable topographical location.

MASKINONGÉ

This county contains a considerable amount of forest acreage, but the percentage of white pine is relatively small, and there are only a few scattered stands located north of the C. P. R., which call for immediate attention.

The blister rust is well established, however, because we found a large percentage of infection, the oldest of which go back to 1925 or 1926.

The Ribes are about as numerous in this county as found in Berthier, and similarly, the *R. glandulosum* with *R. Cynosbati* are the most in evidence.

Out of 48 stands, only 8 are worthy of immediate attention for the reasons above mentioned, 7 could be given protection later on, and 33 completely neglected. Hence out of a total of 16,047 acres, 2,996 demand protection, 1831 to be protected later, and 11,220 to remain unheeded.

JOLIETTE

It was found that this county contained the least quantity of white pine, (with the exception of Argenteuil, but the latter county has not as yet been completely surveyed).

We find the same species of Ribes as in the neighboring counties, and with *R. glandulosum* predominating.

Out of 75 stands with an area of 981 acres of forest, 30 of these stands, with 564 acres require immediate protection, the balance, 43, might be looked after later on.

MONTCALM

With the exception of Ste. Marie Salomée, in the lower part of this county, there are relatively few stands of white pine. At Rawdon, there is quite a colony of white pine where the rust is already at work and has attacked ornamental pines as well.

Almost all the stands inspected in this county, and most particularly those of Rawdon, should be given immediate protection. Therefore, out of an area of 6680 acres, 4680 belong to the first category. The work of eradication is quite simple because of the density of the restricted stands, (40 to 70%). The Ribes are distributed similary as in the neighboring counties.

L'ASSOMPTION

Regardless of the limited area of this county we found a fairly large part containing white pine. There are several fine stands with a density of 60 to 80% white pine, scattered over the county, but found especially in the neighborhood of L'Epiphanie and L'Assomption.

Out of 16 stands which cover an area of 8444 acres of forest, 13 (or 5954 acres) call for prompt attention.

The Blister Rust is quite prominent at l'Assomption and in about the same proportions as in the counties already mentioned. The Ribes are similarly varied and abundant.

TERREBONNE

Due to the fact that this county has relatively but few white pine stands of any importance, we did not undertake any survey work here. However, a little inspection and eradication was done in the plantations of the International Paper Co., at St. Jovite, Cachee river and their Mont Tremblant limits, which work is mentioned in both preceding and following chapters sections.

TWO MOUNTAINS

It is in this county where the Blister Rust was first introduced in this province. Several stands are worthy of protection, especially those of the Sulpiciens at Oka, where our efforts should be directed primarily. In fact the Blister Rust has gained such a foothold in this nursery that it might possibly cause considerable damage within a short time. From our point of view, it is here that our first efforts should be directed towards a systematic eradication, because the pine trees are necessary to control the sand dunes. The work should be carried on in collaboration with the proprietors.

Throughout the rest of the county there are several stands more or less dense, but of small area, which could be protected to advantage. Out of 1545 acres visited, 1530 should be given immediate protection.

ARGENTEUIL

While our inspection of this county is still incomplete, yet the larger portion has been gone over.

There are no large white pine stands here, but there is a certain number of small ones. White Pine is more plentiful in the southwestern section, near the river Outaouais, especially in the municipalities of Chatham and Grenville, and increases as we advance towards the west.

It was within the nurseries of the Department of Lands and Forests, at Lachute, that the Blister Rust was found in 1930, which caused considerable

surprise. Here both the Blister Rust and the Ribes are in evidence in the same proportions as they are in other counties surveyed.

Almost every one of the 492 acres reported in Argenteuil call for immediate protection. We repeat that this county has not been entirely surveyed, and there remains large stretches of White Pine to be looked over.

This is as far west as we have gone, but we hope to continue our investigations into the counties of Papineau, Hull and Pontiac before very long, as the value of this resinous wood decreases in economical importance as we forego protective measures.

RICHELIEU

On the south shore of the St. Lawrence our activities were confined to Richelieu county. Here a surprise awaited us as this, one of the smallest counties visited, contains the largest white pine stands. In fact, out of a total 107,-604 acres of White Pine forest which we located, approximately 61,616 acres are located in this county. Enormous stands in uninterrupted tracts are scattered throughout the several municipalities as can be seen from the map. There are fine White Pine stands, especially around Sorel, while all the other stands include hardly ever less than 40%.

Our inspection of this county leads us to believe that the south shore of the Sr. Lawrence is better adapted to White Pine, than the north shore, and this is further confirmed by the rich stands located in the neighborhood of St. Hyacinthe and Yamaska.

The demand for White Pine is considerable in this section, because of its proximity to the boat building operations of Sorel where large quantities of lumber are used.

There is some slight evidence of the Blister Rust in this county. The cankers, however, are not over 4 or 5 years old, therefore, immediate steps should be taken to eradicate the disease in order to prevent its expansion, because after a large number of trees have been attacked it might be too late to cope with it. The Ribes are also plentiful here, and it would be difficult to eradicate them since the work would have to be carried on within the forests themselves, since they occupy practically all the wooded area.

Our estimates show that there are 46,950 acres which require prompt attention, if we wish to prevent the Blister Rust from spreading over the entire area of this valuable section.

Over all the area visited by us, we inspected, localized and estimated some 107,604 acres of forest where the White Pine is an important factor. Out of this total 70,577 acres have a percentage of over 40% White Pine; 8041 are of less importance, but should be looked after later on, but there are 28,986 acres where immediate steps should be taken to combat the Blister Rust.

While it may appear bold on our part to make the following statement, still we can estimate, approximatively, that there are in the neighborhood of 619,667,000 M. feet of White Pine available in the territory visited.

Even though the ravages of the Blister Rust have not as yet been really serious, still it must be born in mind that it is here, and can attain stupendous proportions if not checked and controlled.

The work done last year has allowed us to conclude that this disease is of recent origin in this province, and this accounts for the limited area damaged up to date. This does not minimize the virulency of the Blister rust however, since it has spread to almost every inhabited sections of this province in a relatively short time. Consequently, it would be folly to say that the White Pine Blister Rust is not dangerous and that it cannot make any progress here. It is well to state here that it would be difficult to find, during the course of the month of August, bushes of Ribes, wild or cultivated, which are totally free of the disease.

While the Ribes exists here in considerable proportions, their eradication would not be very difficult for the important stands. Judging from the protection work done at the Berthierville nursery, the cost would not be very great.

PROTECTION OF THE BERTHIERVILLE NURSERY

We have already mentioned that, at the start of our season's program, the nurseries were to be given our first attention. To this effect we have devoted a large part of our time, as well as that of our personnel, to the establishment of a protective zone around the Provincial nursery at Berthier, and to its annex at Ste. Philomene.

Naturally this undertaking, should have been the first to receive our attention. The danger was quite apparent since the Blister Rust was already in evidence in the neighboring forest. In fact, last spring the Blister Rust was found within the nursery on trees of a certain age, also within the Ste. Philomene nursery on trees of 5 or 6 years, where a considerable number had been infected 4 or 5 years. We also found the presence of Ribes in large quantity within the nursery and its neighborhood.

Immediately it was decided to clean up the Berthier nursery, a staff was organized and instructed in this type of work, with the view of doing a complete job.

Briefly, this is how we proceeded last year. The crew was composed of 22 men, including a foreman, a compass man and 2 recorders and 18 men who were placed in line 10 feet apart, preceeded by the compass, or lineman, while the two recorders followed at equal distance. In this way one acre was covered at a time. The proceedure was as follows. The compass or lineman dragged a chain which served to indicate each 100 feet of the ground covered, and the two recorders took notes of the quantity and species of Ribes found as well as the location of each bush. This information was very useful in making out maps and, later, when it is desired to make another clean up, it will be easy to locate the bushes of Ribes.

ERADICATION

Berthier Nursery

Area	Grande-Côte	Ste. Philomene
Of the Nurseries	263.4 acres	455.6 acres
Wooded area Nurseries	152.25 "	230.0 "
Total Radius	800.95 "	616.7 "
Radius—Wooded area	315.10 "	592.1 "
Totals	1,064.25 acres	1,072 3 acres

Frequency of Ribes	Nursery	Radius	Nursery	Radius
Ribes glandulosum	285	3,935	332	2,121
" triste	55	1,198	31	229
" cynosbati	63	108	20	123
" americanum (S)	.....	.....	20	163
Ribes nigrum	.....	25	.....	40
" vulgare	.....	17	.....	4
" grossularia	.....	5	.....	.....
" americanum (C)	.....	29	.....	10
Totals	5,720		3,080	
General Total	(Bushes of Ribes)		8,860	
Average per acre (wooded)	6.7			
General Average	4.1			

The protection of a nursery against the White Pine Rust calls for more precautions than when it applies to an ordinary white pine forest. The experience acquired in the United States shows that when applied to the former all trace of the Ribes must be removed within a radius of 1500 feet, while the latter calls for a radius of 900 feet, in order to attain the best protection possible. The total area of the nursery in question being 263.4 acres, of which 111.05 are wooded, we had to establish a zone covering an area of 800.95 acres outside of its limits, hence a total of 1064.35 acres. The wooded space had an area of 426.15 acres of which 111.05 served as nursery. This was the most difficult part

to go over, also the one which concealed the wild Ribes, and in addition to the actual work, it was necessary to go over all of the open ground, including the shores of the creeks and the St. Lawrence river, and along the fences in order to eliminate every bush within the zone. Lastly, we removed the cultivated Ribes, i e; *R. vulgare*, *Ribes Grossularia*, and *R. Nigrum*, wherever they appeared on the private properties within this radius of 1500 feet, and the last, R. nigrum, up to a distance of one mile. (22) The protection of the nursery and plantation of Ste. Philomene was difficult to realize, since the wooded area was more extensive than the preceeding, as shown on Table 3.

This table shows conclusively the importance of giving the necessary protection to our two forest nurseries, since they were completely circled by Ribes and in such quantities that it was sometimes necessary for 22 men to work for an hour to remove a single stand. One of these particular stands, composed of *Ribes americanum* had an area of 1375 square feet.

The *Ribes glandulosum*, especially where the land is humid, predominates here as it does elsewhere. The *Ribes triste* var. *albinervum* unlike the former species, predominates where the land is drier or less acid. The shores of the creeks often conceal dense clumps of *Ribes americanum* of considerable area.

It will be seen, therefore, that the year 1931 is the milestone for the elimination of the Blister Rust, and its source of infection, in the Berthier nursery. But aside from the work already done precautions must be taken to the end of maintaining this artificial immunity, because according to several years experience in the United States it appears that, quite often, the bushes even though they have been uprooted and removed, grow again. Furthermore, while the work of eradication is taking place a certain number of Ribes may be overlooked, due to their limited size, and besides the seeds which may have been dormant at the time may germinate later on. These conclusions explain the reason why up to 90% of bushes were found to have regrown while going over the same area later on. Therefore, in order to avoid any chances that the disease returns after a certain time, it is necessary to eradicate again after 3 or 4 years. Another precaution that should be taken, is that no pine shrubs should be sent out for planting before three years have elapsed after the eradication has taken place. This will avoid the possibility of spreading the disease before it has been found to exist, since it requires 3 years after the infection has taken root before the symtoms are clearly in evidence on the boughs and on the stems.

CONCLUSIONS

At the time of the American conference, which took place at Littleton N. H. in 1930, to consider the White Pine Blister Rust control, Mr. Detwiller, Director of the section for the protection against the Blister Rust in the United States, sent the following message to the congress. "Canada's failure to apply rust control and the open question as to how far we shall succeed in secu-

ring extensive control in the West indicates white pine values of future will be greatly enhanced. This should be a stimulus to control in Eastern and Lake states since strobus is a comparatively resistant species and rusts easily and cheaply controlled."

Today, however, after the work we have just accomplished, we cannot be absolutely sure of its success, but we believe that we have taken the right steps towards the eradication of the disease in the Province of Quebec.

We believe that we have demonstrated, through this humble contribution, the extent and the importance of this new field of action, and what we have already done is at least a good start against the grave menace of the Blister Rust.

APPENDIX

In order to facilitate the task of those who might find it necessary to have particulars of the different species of Ribes existing in the Province of Quebec, they will find in the following pages a short, yet clear and simple, description of these plants.

Dichotomic key of the species of Ribes.

I.—Wild Species:

A Glabrous stems.
B. Leaves covered with resinous glands..*R. americanum.*
BB. Leaves not covered with resinous glands.
C. Stems having a strong polecat odor...*R. glandulosum.*
C.C. Stems not having any strong odor....*R. triste* var. *albinervum.*
AA. Thorny stems.
B. Glabrous leaves.
C. Leaves having sharp pointed lobes....*R. hirtellum.*
CC. Leaves having rounded lobes.....*R. oxyacanthoides*
BB. Leaves pubescent.
C. Leaves with deep lobes.....*R. lacustre*
CC. Leaves with small lobes.....*R. Cynosbati*

II—Cultivated Species:

A. Leaves covered with resinous glands.
B. Glands on both sides of the leaves.....*R. americanum*
BB. Glands on the under side only.....*R. nigrum*
AA. Leaves not covered with resinous glands.
B. Stems having unbranched or triple-branched thorns or with 3 branches.....*R. Grossularia*
BB. Glabrous stems.....*R. vulgare*

FIG. 3.—R. glandulosum. Gadelier couché. Shunk currant.

FIG. 4.—R. Triste var. albinervum. Gadelier des marais. Swamp red currant.

FIG. 5.—R. hirtella. Groseillier sauvage.
Smooth gooseberry.

FIG. 6.—R. oxyacanthoides. Groseillier fausse-épine.
Northern smooth gooseberry.

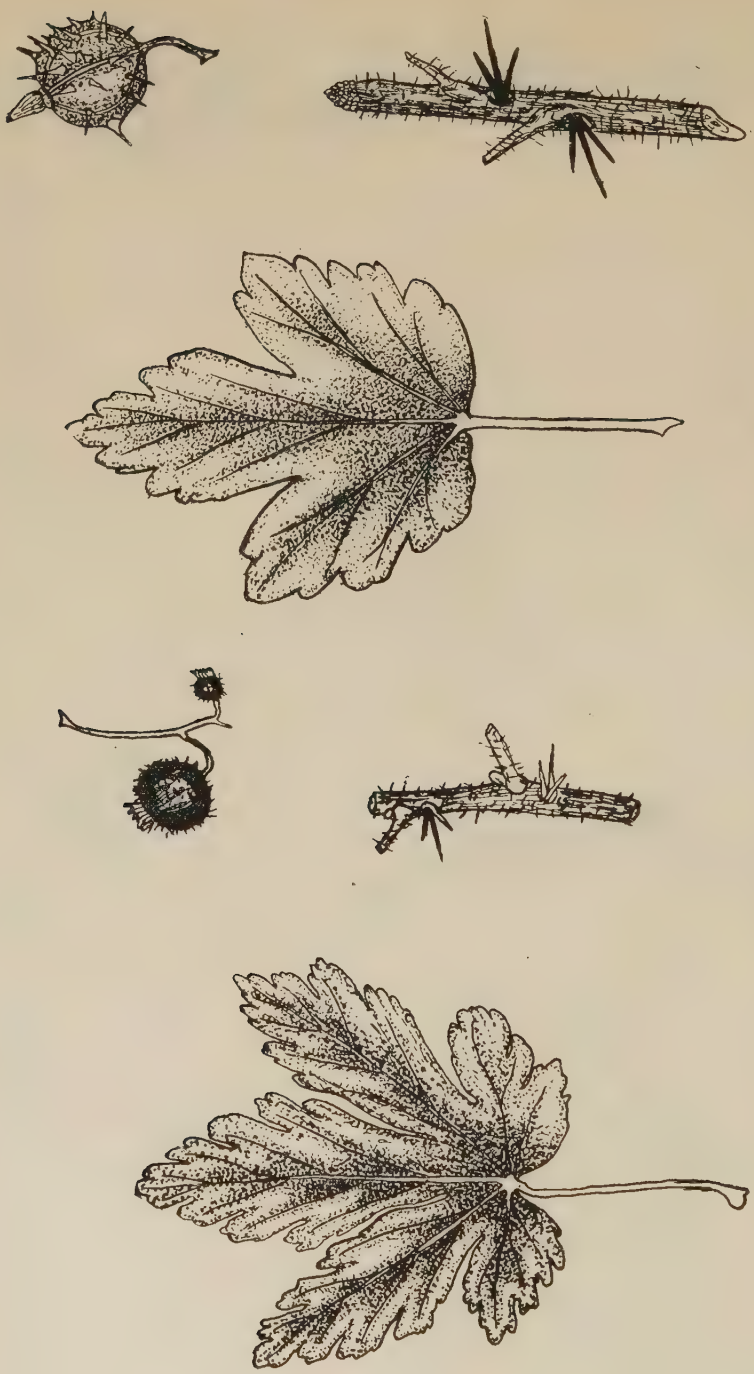

FIG. 7.—R. cynosbati. Groseillier ronce de chien. Prickly gooseberry.

FIG. 8.—R. lacustre. Groseillier des lacs. Prickly currant.

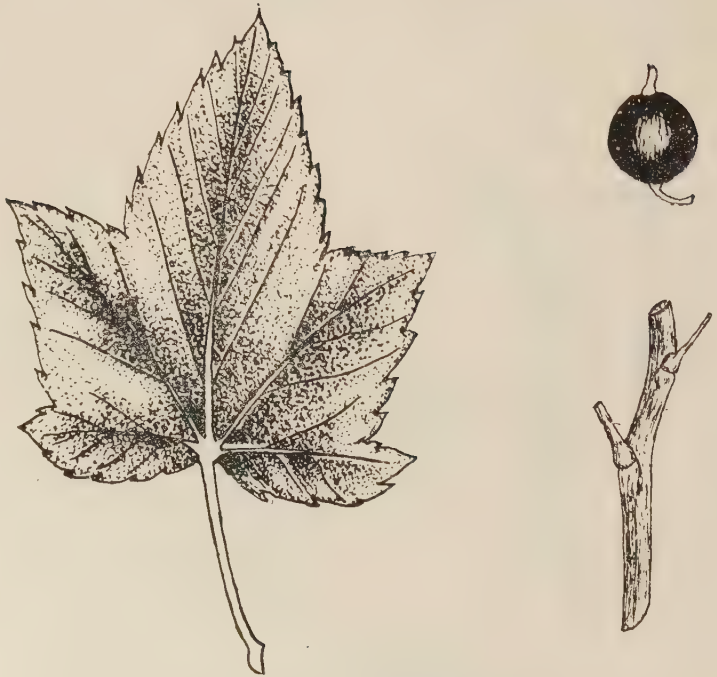

FIG. 9.—R. americana. Gadelier noir sauvage. Wild black currant.

RIBES CULTIVATED

FIG. 10.—R. nigrum. Cassis. Black currant (European).

FIG. 12.—R. vulgare. Gadelier commun. Red currant.

FIG. 11.—R. grossularia. Groseillier cultivé. Garden gooseberry.

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A DISEASE OF THE POTATO

Spindling Tuber

By Bernard Baribeau, B.S.A., Chief Potato Inspector, Ste. Anne de la Pocatière, Que.

The disease called "Spindling Tuber" of the Potato is not widely distributed in our Province, but it is one of the most serious diseases of the potato.—*It has the effect of decreasing progressively both the vigour and the yield,* until the latter is practically nil after a certain number of years, particularly if the same seed is used over and over again and always within the same locality. It is true, however, that this disease is more apparent in the strains already impoverished through lengthened localised cultivation, and through lack of care in selecting the seed.

The effects of the disease are quite apparent through the mottling and curling of the leaves, but, up to date, no definite explanation of a satisfactory nature has been found for its existence. There may not be any exageration in saying that the cause of the disease is complicated and often associated with other virulent diseases.

The term "Spindling Tuber" is employed to describe potato sprouts which are very thin, pale, and especially long and slim if they develop in a cellar or in depositories which are still darker and warmer. (Fig. 1) We have often noticed that the sprouts are thread-like, pale and weak and dry up rapidly when exposed to the air; that they will break readily when submitted to the least shock. In a few cases we have noticed that the different parts of the tuber are attacked unevenly and that the disease seems to diminish progressively from the top to the base. The terminal sprout of these tubers is almost normal, while the lateral sprouts are more or less thin and become slimmer as they recede from the top.

In as far as the use of these tubers for seed purposes is concerned, they are most dangerous because their condition may be doubtful even to those who are charged with the selection of the seed as it is barely noticeable, especially when the sprouts are still quite short.

Needless to add that all tubers attacked by this disease, whether partially or totally, or whose sprouts appear to lack strength should *invariably* be rejected as seed. Even if such seed should produce a certain quantity of potatoes, the fact that they are partly infected will reduce the yield below normal, besides their tubers might be used again in future planting.

We wish to make the following recommendation, that all the directors of the various agricultural Associations of the Province and, more particularly, that all the farmers refuse to accept any seed potatoes other than those that come from fields which have passed a satisfactory inspection and, furthermore, they insist that each bag or other container of seed potatoes bear the official certified tag in accordance with the requirements of the law, which make this procedure compulsory. Thus only can they protect themselves against an inferior merchandise. The fact that potatoes are good for consumption is not a guarantee against diseases which must be guarded against at all costs.

Therefore, it will be seen that it is absolutely necessary to give greater care, than has been given heretofore, to the potato seed. Thus diseases will ultimately be more easily and more economically controlled, or at least kept in check, and this will serve to standardize the product, especially to increase the yield and the quality.

BENT GRASS AND DOG GRASS

By Rev. Prof. Louis-Marie, Oka Agr. Institute.

It has seemed to us that the Society for the Protection of the Plants should devote its attention to systematic botany, because to name the plants by their proper names is not only a useful matter but a very essential one, while to change the name of a plant is erroneous and contrary to the rules of all the Botanical congresses held in the past.

It is most regrettable that the early European Botanists who made a study of our Canadian flora were unduly conservative and their studies only too often superficials. They homologated a large number of our plants with corresponding European species, consequently they brought about lenghty misunderstandings which are disappearing very slowly one by one from our practical botanical literature.

Dr. M. O. Malte, Federal Agrostologist, published, in 1928 and again this year, two remarkable contributions whose conclusions are most important to all the members of this society since they insist upon changing the names of two gramineous groups of first importance, and without passing any comments thereon we are giving herewith the changes made in the names of our Bent and Dog grasses.

I.—Agrostis — Agrostide — Bent Grasses

(See * "Commercial Bent Grasses in Canada, by M. O. Malte, 1928)

1.—Agrostis stolonifera L. (syn.: A. alba, A. vulgaris) Agrostide stolonifera

a. Var. major (Gaud) Farw. (syn.: A. alba, var. major; A. palustris)

b. Var. compacta Hartm. (syn. A. maritima; probably A. palustris) Creeping bent, Carpet bent.

2.—A tenuis Sibth. — Agrostide tenue — Rhode Island bent, Browntop, PEI. bent, Colonial bent.

(syn.: A. vulgaris, A. alba, var. vulgaris, A. capillaris)

a. Var. aristata (Hartm.) Holmb. (syn.: A. vulgaris, var. aristata)

b. Var setulosa (Murb.) Holmb. (syn.: A. vulgaris, var. setulosa)

(*) The two mentioned contributions although published concurently in 1928 and 1932, their original apparition was in the Annual Report of the National Museum of Canada for 1928 and 1930 respectively. Consequently, the new names published have priority over all others that may have appeared thereafter.

II. Agropyron — Dog Grass — Awned Wheat Grass

(See "The so-called Agropyron caninum (L.) Beauv. of North America" by M. O. Malte 1932)

1.—Agropyron trachycaulum (Link) Malte. Dog Grass

a. Var. tenerum (Vas.) Malte
(syn. A. tenerum, A. pseudorepens, A. novæ-angliae, A. caninum, var. tenerum)

b. Var. glaucescens Malte, rare, new variety known only at Cap à l'Aigle in the Province of Quebec.

c. Var. trichocoleum (Piper) Malte.
(syn.: A. tenerum, var. ciliatum; A. caninum, var. tenerum, f. ciliatum.

d. Var. Fernarldo (Pease & Moore) Malte.
(syn.: A. caninum, var. tenerum, f. Fernaldii)

e. Var. unilateral (Vasey) Malte.
(syn.; A. caninum AA., A. Richardsoni, A. unilateral, A. violascens, A. caninoids, in Beal).

f. Var. caerulescens Malte.
New variety in western Canada (Alberta, Bristish Columbia)

g. Var. ciliatum (Scribn, & Sm.) Malte.
(syn.: A. Richardsoni, var. ciliatum, A. canium, f. pubescens.

h. Var. glaucum (Pease & Moore) Malte.
(syn.: A. caninum, f. glaucum)

i. Var. pilosiglume Malte.
New variety harvested at Victoria, Vancouver.

j. Var. hirsutum Malte.
New variety, also found at Victoria and Vancouver.

SUMMARY OF THE INSPECTION OF POTATO FIELDS AND SUPERIORITY OF CERTIFIED SEED

By B. Baribeau, Chief Potato Inspector, Ste. Anne de la Pocatière, Que.

Has the certification of seed potatoes made any effective progress during the last five years?

The following brief outline of what has been accomplished coupled with detailed tables will serve better than anything else to convince all concerned.

Quebec potato growers were amongst the first to appreciate the practical value of the system of inspection and certification of seed potatoes, and the results shown in the geographical map of Quebec (Fig. 1) and Table attached are definite proofs of the success of the system.

The map, divided by counties, for the year 1931, shows the number of acres which were planted with certified seed potatoes, and subjected to inspection.

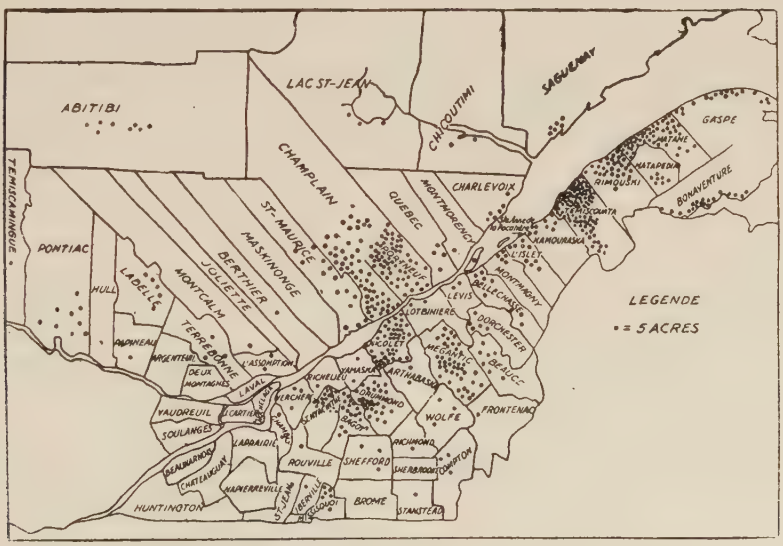

FIG. 1.—Distribution of certified potato growing centres in the province of Quebec during 1931. Each dot represents 5 acres.

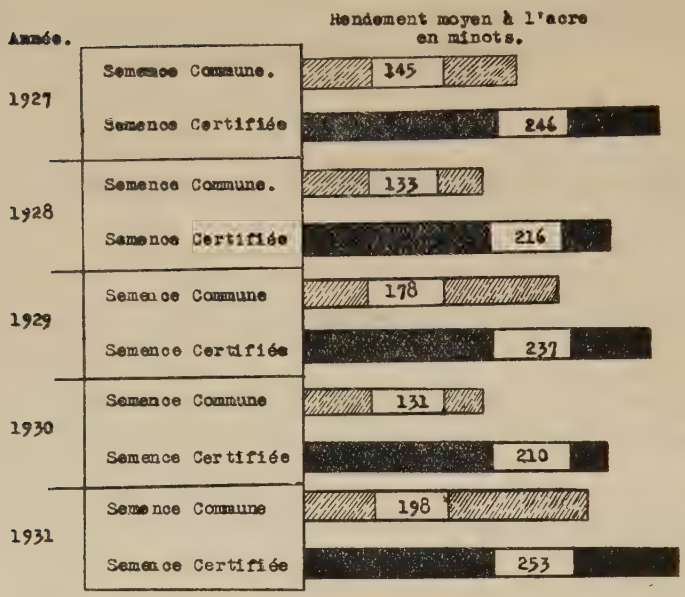

FIG. 2.—Comparison between yields obtained from certified and common potato seeds during the period 1927-1931 in Quebec. Average in bushels per acre.

Summary of potato Field Inspection Work

Year	Number applications received	Number fields inspected	Number acres inspected	Number fields accepted	Number acres accepted	Percentage of fields accepted	Percentage of acres accepted
1927.....	319	398	590	261	384.6	65.6	65.2
1928.....	746	807	1107.3	548	724.4	67.9	65.4
1929.....	1287	1640	3091.3	903	1682.1	55.0	54.4
1930.....	1567	2019	3168.7	1138	1801.8	56.4	56.8
1931.....	1743	2069	3249.7	1373	2086.3	66.4	66.5

Number of fields rejected in 1931 with reasons

Black Leg.....	57 fields	Too close to fields affected by Mosaic and Leaf Roll.....	83
Leaf Roll.....	26 "	Presence of foreign varieties.....	48
Mosaic.....	271 "	Fields poorly cultivated, lack of vigor, frost, etc., etc.....	46
Wilt.....	37 "		
Late Blight.....	128 "		
Total fields rejected.....	696 "	No. total acres rejected.....	1163.3

No. acres inspected	G. M.	2678.5		No. acres accepted	G. M.	1625.5
" " "	I. C.	337.7		" " "	I. C.	276.6
" " "	Dooley	158.1		" " "	Dooley	120.2
" " "	other var.	75.4		" " "	other var.	64.0

It is most encouraging to note the broad improvements that have been brought about through the use of certified seed potatoes during the last five years. Particular attention is called to the foregoing tables wherein it is shown that in 1927 the number of applicants were 319, while they reached 1743 in 1931, an increase of 1424 in five years. In 1927, the number of fields inspected were 398, and in 1931, 2069, an increase of 1671 fields. The extent of inspection in 1927 covered 590 acres, whereas in 1931 it reached 3249.7 acres, an increase of 2659.7 acres. Similar comparisons apply to the number of fields and acres accepted after inspection.

To convince any one who might still have some doubts as to the value of certified seed potatoes, we are reproducing a chart showing the wide difference in yields between the common and the certified seed potatoes for the last five years, (1927 to 1931 inclusive). The summary of this chart shows that the average yield per acre for the common potato was 157 bushels, while the yield from certified potatoes attained 233, or an increase of 76 bushels in favor of the certified seed. It follows that the average yield from common seed is much inferior to that of the certified seed. At first sight this difference does not appear to be of such a great extent, but when multiplied by the number of acres planted with potatoes, which reaches 165,000 acres, the result amounts to the enormous sum of 12½ million bushels, which equals about 50% of our annual production.

In the cultivation of potatoes the profits are not governed by the total yield per acre, but by the yield over and above the cost of production, that is, what is left over after deducting the cost of cultivating an acre. Current practice has established that in order to defray expenses the minimum yield must be 140 bushels per acre. Consequently, if the yield is inferior to 140 bushels the producer must sustain a loss since it is necessary to obtain 140 bushels to meet expenses.

For example, let us take the average yield of 150 bushels for common seed and 233 bushels for certified seed and deduct from each amount the 140 bushels required to cover the cost of production. It will be seen that the producers of common potatoes can only count upon 17 bushels per acre as profit, whereas those using certified seed obtain 93 bushels. It will be seen that in order to obtain as much revenue as the producer of certified seed, the user of common seed must cultivate five times more acreage. EXAMPLE: Let us take 3 acres, as a basis, of certified seed with an average yield of 233 bushels per acre:

3 x 233 = 699	bushels	total yield for	3	acres
140 x 3 = 420	"	cost of production		"
699 − 420 = 279	"	profit		"

In the case of common seed the acreage would have to be five times larger to arrive at about the same revenue.

Now, let us take 15 acres with a yield of 157 bushels:

15	x	157 = 2355	bushels,	yield for 15 acres.
140	x	15 = 2100	"	cost of production for 15 acres,
2355	–	2100 = 255	"	profit " " "

It follows that if all the producers of potatoes in this province used certified seed, the acreage cultivated could be easily reduced by one-third and still obtain a better yield than at present with an increased revenue per acre, and a better quality, besides reduce to a minimum the losses caused by diseases. Consequently, certified seed is means which must be adopted to increase the yield of potatoes and, at the same time, it will contribute largely towards the solution of one of our greatest agricultural problems, that of economic production.

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